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U.S. Efforts To Address Global Climate Change

Report To Congress

**Prepared jointly by the
U.S. Department of State
and the U.S. Environmental Protection Agency**

U.S. EFFORTS TO ADDRESS GLOBAL CLIMATE CHANGE

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INTRODUCTION

Addressing Climate Change

The nature of human existence on the Earth has changed dramatically over the last century. The world population has increased threefold since 1900. Industrial production has increased by a factor of fifty, four-fifths of it since 1950. The world economy has expanded twenty times, and consumption of fossil fuels has grown by a factor of thirty. The concentration of carbon dioxide in the atmosphere has increased by twenty percent since pre-industrial times. In the tropics, ten trees are cut for each one planted; in Africa, this ratio is 29 to 1. While thirty percent of Ethiopia was covered by forest forty years ago, today only about one percent is so covered. Human activity is changing the features of the Earth; in particular, much of this activity is affecting the chemical composition of the earth's atmosphere, possibly changing the Earth's climate.

The possibility of global climate change has become an issue of great concern in the international community and within the United States. Much is unknown, however, about whether or not such changes have been detected, when and how they might occur, or what can be done about it. In spite of these unknowns, the international community is now reaching a consensus on a process through which the potential for climate change may be addressed, a consensus and process in which the United States is participating.

Any process to address global climate change must include the following elements:

- scientific research on climate change to reduce current uncertainties about the operation of the climate system and to improve our understanding of the impacts of human activities on future climate;
- the assessment of environmental, social and economic impacts of future change;
- the evaluation of policy options and practices to limit, mitigate or adapt to this change, including an assessment of their effectiveness and social and economic impacts; and,
- the development and implementation of feasible and cost-effective policies and practices.

This process is shaped by a number of constraints. First, it should incorporate a recognition that many scientific and economic uncertainties remain about possible climate

change, its impacts, and societal responses. Much remains to be known about the magnitude and extent of a possible climate change. Better understanding is needed of such issues as the role of clouds and oceans, the role of the biosphere and the rest of the earth system, and potential feedback mechanisms. A quantification is needed of the sources and sinks of greenhouse gases. More needs to be known about the environmental, social, and economic effects of climate change. Although some environmentally useful actions have been identified to limit or adapt to possible climate change, no comprehensive exploration has been made of the range of possible options for addressing climate change or of their potential costs and benefits.

Second, the process must involve international cooperation, both in the investigation of uncertainties and the development of response strategies. Although unilateral actions by a single nation can contribute in the short run to delaying the build-up of greenhouse gases, they will be ineffective ultimately unless other nations follow suit. For example, China plans to double its use of coal by the year 2000, and India plans to triple its use of coal by this time. If these plans are carried out, coal use, and greenhouse gas emissions, from just these two countries will exceed those of all the industrialized countries combined, making any efforts undertaken by the industrialized nations without India and China ineffective. Global climate change is inherently an international issue that can be addressed effectively only by all nations working in concert.

Third, it should recognize the sovereign right of each nation to manage its own agriculture, industry, and natural resources. Although international organizations can work to reduce scientific and economic uncertainties and develop approaches to addressing climate change, each nation must be able develop and implement its own national strategy that is compatible with its level of economic development and national priorities.

The approach that emerges from these requirements and constraints is one in which the international community works to resolve uncertainties and to reach an agreement on steps to address climate change, with each nation developing a strategy to implement measures called for under the agreement. While these uncertainties are being resolved and such an agreement developed, a U.S. national strategy can be developed that includes measures to limit or adapt to potential climate change that can be justified for other reasons.

U.S. Efforts to Address Climate Change

U.S. efforts to address potential global climate change consists of:

- promoting an international consensus on climate change issues, including the current state of scientific knowledge of climate change, the potential range of impacts of such change and possible policy options, including the elements of a framework convention on climate;

- o entering into international negotiations for a framework convention on climate change that would provide a more formal mechanism for international cooperation in understanding the issue and developing coordinated strategies to address it;

- o developing, implementing, and promoting policies and practices that limit or adapt to climate change and are justified for reasons other than climate change, such as promoting increased energy efficiency, reducing CFC emissions and other greenhouse gases, stopping deforestation and promoting reforestation and wise land use; and,

- o continuing to support ongoing research and monitoring programs and searching for greater international support of research programs that will reduce remaining uncertainties.

The United States is a leader in international efforts to reach a consensus on climate change. The primary forum for these efforts is the Intergovernmental Panel for Climate Change (IPCC). The IPCC is an ad hoc body, jointly established by the United Nations Environment Programme and the World Meteorological Organization, to assess the state of knowledge about climate change and its impacts and to consider possible response strategies. Recognizing that extensive cross-disciplinary work and participation by many nations was required to address the climate change issue, the IPCC established three Working Groups to (1) assess available scientific information; (2) assess natural-resource and socio-economic impacts; and (3) formulate response strategies. These Working Groups prepared reports that were submitted to the IPCC and compiled into a comprehensive first assessment report in August of 1990.

As part of the formulation of response strategies, the third Working Group, chaired by the United States, has developed an assessment of the possible elements of a framework climate convention. President Bush, at the 1989 Malta Summit with Chairman Gorbachev, offered to host a conference to initiate the negotiation of this convention after the IPCC submits its first assessment report. This offer was accepted by the international community, and the first negotiating session will be held in Washington, D.C., in February of 1991. The President also convened, in April of 1990, an international meeting of top level scientific, environmental, and economic officials on science and economics research related to global change.

The United States is also participating in a number of national and international research efforts to address the uncertainties of climate change. The first of these is the World Climate Program, initiated in 1979 and administered by WMO, UNEP, and ICSU. A more recent and broader international research effort is the International Geosphere- Biosphere Programme (IGBP), launched in September of 1986 by the International Council of Scientific Unions (ICSU). The United States has developed several national programs that are linked to these two efforts, including the Global Change Research program, coordinated by the Committee on Earth and Environmental Sciences (CEES). Interagency coordination regarding economic and policy issues is being led by the Domestic Policy Council under the guidance of the President's Science Adviser. A number of agencies, including the Departments of Agriculture, Interior,

Commerce, Energy, and the Environmental Protection Agency, are conducting research on climate change. Some of these research programs are cooperative efforts with such nations as France, Canada, China, the USSR, Brazil, and others.

The United States is undertaking a number of steps to limit greenhouse gas emissions that can be justified for other reasons. The President has directed the Secretary of Energy to develop a National Energy Strategy that can meet the nation's energy needs while protecting health, safety, and environment. In addition, the Department of Energy (DOE) has a number of other programs to develop alternative and renewable sources of energy and improve energy efficiency. The Agency for International Development (AID) is promoting energy efficiency and exploring alternative and renewable sources of energy internationally. In an action that will reduce emissions of a major class of greenhouse gases, the United States is participating in a world-wide phase-out of CFCs by the year 2000 under the Montreal Protocol on Substances that Deplete the Ozone Layer. The Clean Air Act amendments, as implemented by the Environmental Protection Agency (EPA) offer substantial reductions in a number of greenhouse gases and encourages energy efficiency. In addition to international efforts to prevent deforestation and promote reforestation through the Department of Agriculture (DOA), the Department of State and AID, the United States is undertaking a multi-year initiative to plant a billion trees a year on private land across America and is launching a community trees program that is designed to plant another thirty million trees in communities across the country.

The Report to Congress

The U.S. Congress gave voice to its concern about the need for a process to address climate change in the Global Climate Protection Act of 1987 (P.L. 100-204). This Act requires, among other things, the Secretary of State and the Administrator of the Environmental Protection Agency to submit jointly to Congress a report that includes:

> (1) a summary analysis of current international scientific understanding of the greenhouse effect, including its environmental and health consequences;
>
> (2) an assessment of United States efforts to gain international cooperation in limiting global climate change; and
>
> (3) a description of the strategy by which the United States intends to seek further international cooperation to limit global climate change."

This report fulfills this mandate. Section 1 of this report introduces the science and potential impacts of climate change and possible response actions. Section 2 describes the U.S. approach to climate change, summarizing statements by Congress and the Administration. Section 3 outlines the many programs agencies are undertaking that comprise this approach. Section 4 describes U.S. policy coordination on climate change issues, while Section 5 summarizes future

efforts to address climate change. The current international scientific understanding and potential impacts of climate change and potential response strategies are summarized in Appendix B in the form of the IPCC's First Assessment Report, while Appendix A contains the text of statements by the White House.

Because domestic and international efforts to address climate change are inextricably connected, this report presents a comprehensive description of U.S. actions to address climate change. Many domestic research programs, such as the Global Change Research Program, are components of international research programs. Some domestic actions that can limit climate change, such as reducing CFC emissions, are driven in part by international agreements. Others, such as the development and use of more energy-efficient technologies, can serve as models for or be adopted by other nations. A report on U.S. efforts to gain international cooperation to limit global climate change that failed to include these domestic programs would be incomplete.

1. BACKGROUND

The global community has become aware over the past several years of a need to address climate change. Premature actions to do so, however, would be fraught with difficulties. As Robert M. White, the President of the National Academy of Engineering, stated in a speech before the National Academy of Sciences, "soundly based policy actions [to address climate change] must emerge from our knowledge of causes and effects and the uncertainties in that knowledge weighed against the risks, consequences and costs of action. We know much about the former and little about the latter. Our knowledge of the likely causes is well documented. Our knowledge of the climate system response to these causes is extensive but fraught with uncertainty. Our knowledge of the social and economic consequences is weak and speculative." This chapter briefly describes the theoretical basis of climate change and some of the uncertainties surrounding the phenomenon, its impacts and possible response strategies, and a process through which it can be addressed.

1.1. THE CLIMATE SYSTEM

The earth's climate is not a fixed element in the environment. It has varied dramatically over the past, from conditions some 5° to 10°C warmer than today's temperatures millions of years ago to glacial conditions 18,000 years ago. The earth has warmed some 4°C (7°F) since the last ice age, but has remained at a relatively constant temperature over the last 5,000 years, with average variations from the long-term mean temperature being less than about 1°C.

The climate system includes the atmosphere, oceans, land surface, cryosphere (glacial, mountain, and sea ice) and some aspects of the biosphere. These components interact to determine the climate. The weather, which is the instantaneous state of this system, is quite variable and turbulent; useful predictions of its chaotic and random behavior are possible only a few days in advance. The climate, which is the average of the weather over many years (by convention, 30 years), is much more stable. However, even the climate is subject to variations that can disguise regional trends and trends on timescales of less than one hundred years.

Climate is controlled by many factors, including variations in solar irradiance, changes in the shape of the Earth's orbit, by the height and extent of the continents, and, of present concern, by the composition of the Earth's atmosphere. Excluding water vapor, more than 99.9 percent of the atmosphere is comprised of nitrogen, oxygen, and unreactive noble gases. The remaining fraction is composed of trace gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These trace gases are relatively transparent to incoming short-wave radiation (sunlight), but opaque to longer wavelength infrared radiation emitted or reflected by the earth's surface and the lower atmosphere, thus serving to retain the warmth that radiates back from the earth. Because this effect is similar to the effect of glass in a greenhouse, it has been labeled the "greenhouse effect" and the gases "greenhouse gases."

1.2. GREENHOUSE GASES

Greenhouse gases, some of which do not occur in nature, are accumulating in the atmosphere. The concentration of CO_2 has increased 25 percent since the start of the industrial revolution. Measurements taken at Mauna Loa Observatory, Hawaii, show an increase from 315 to 350 parts per million (ppm) in the atmosphere since 1958, a concentration that is increasing at a rate of about 0.4 percent per year (Figure 1). This can be compared to a pre-industrial (1850) level of 270-280 ppm. The concentration of methane, now 1.7 ppm, has more than doubled over the last three centuries, and is increasing at a rate of 1 percent per year. The nitrous oxide concentration has increased 5 to 10 percent since the beginning of the industrial age, and is now .310 ppm. Chlorofluorocarbons (CFCs), man-made greenhouse gases, were only introduced into the atmosphere during this century, but have been increasing at a rate of 4 percent per year since 1978.

The rise in carbon dioxide in the atmosphere is a result of both the burning of fossil fuels and deforestation. CFCs, halons, and related compounds (e.g., methyl chloroform) are man-made compounds, and are released during or after their use as refrigerants, solvents, fire-extinguishers, and aerosol propellants. CFCs are released either during manufacture and use or are trapped in products such as air conditioners and refrigerators, spray cans, and structural and flexible foam products. There is much more uncertainty about the nature of methane emissions, but the principal sources are rice cultivation, animal husbandry, landfills, and coal seams. The increase in methane is probably due both to increases in the number of sources and to changes in atmospheric chemistry. The cause of the increase in nitrous oxide is highly uncertain, but the use of nitrogenous fertilizer, land clearing, biomass burning, and fossil-fuel combustion appear to have contributed. Other chemicals are being released to the atmosphere, such as carbon monoxide (CO) and nitrogen oxides (NO_x), that are changing the chemistry of the atmosphere. This is altering the atmosphere's oxidation ability and changing the rate of degradation of some of the greenhouse gases. Table 1 lists these greenhouse gases and their sources.

The relative importance of these trace gases in creating the greenhouse effect varies. Molecule for molecule, some gases are more effective in absorbing radiation than others. For example, CFCs are tens of thousands of times more effective in absorbing infrared radiation than CO_2, while methane is about 25 times more effective. In addition, the gases have varying lifetimes in the atmosphere. Carbon dioxide has a lifetime of up to 500 years, CFCs have lifetimes of 75 to 100 years, and methane has a lifetime of only 5 to 10 years. These greenhouse gases naturally degrade in the atmosphere over time or are removed as part of the natural cycling of elements through the ecosystem (biogeochemical cycling).

Because these gases are currently being released into the atmosphere faster than they are being removed, their concentrations in the atmosphere are expected to intensify even if global emissions remain constant. With emissions held constant at 1985 levels, the concentration of CO_2 could reach 440-500 ppm by 2100, compared with about 350 ppm today. CFC

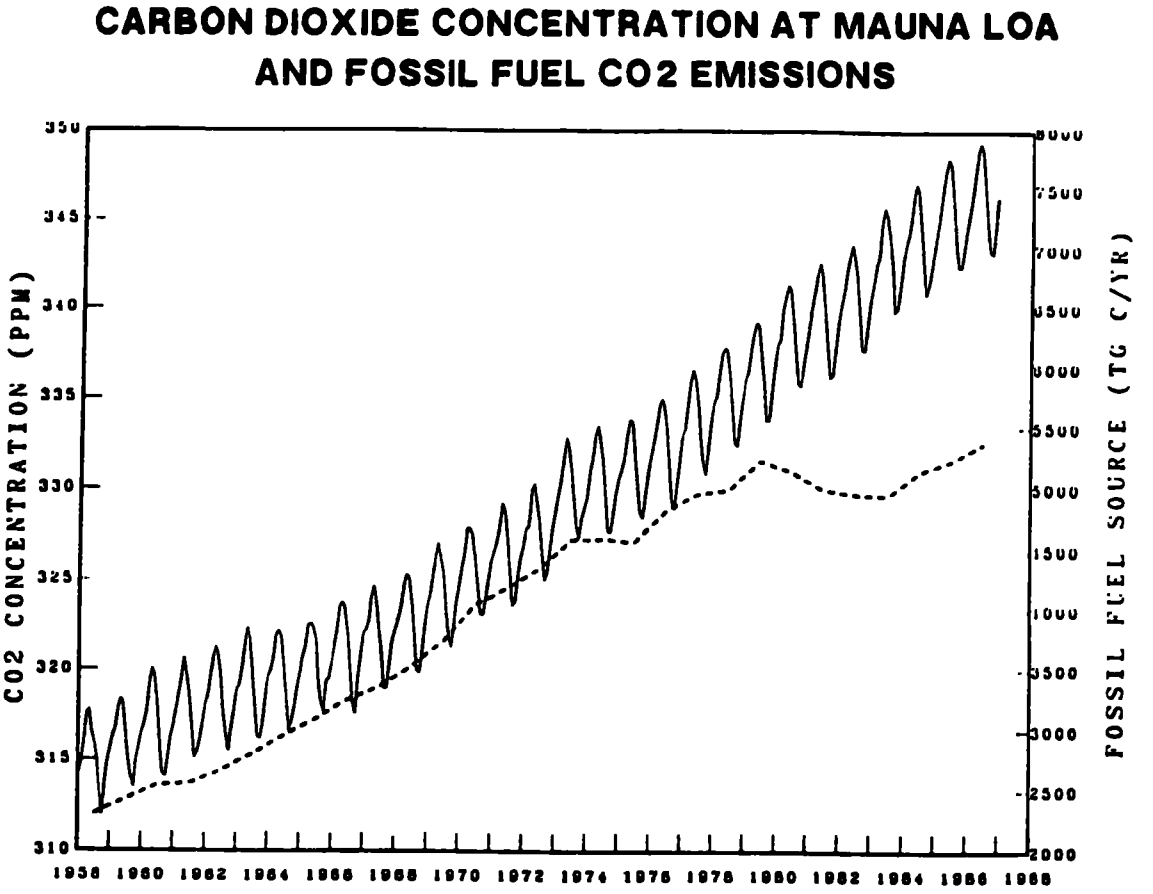


Figure 1. The solid line depicts monthly concentrations of atmospheric CO_2 at Mauna Loa Observatory, Hawaii. The yearly oscillation is explained mainly by the annual cycle of photosynthesis and respiration of plants in the northern hemisphere. The dashed line represents the annual emissions of CO_2, in units of carbon, due to fossil fuel combustion.

Table 1. Important trace gases with anthropogenic sources that affect the composition of the atmosphere and climate

Gas	Common Name	Primary anthropogenic sources	Greenhouse gas?	Chemical Interactions with tropospheric composition?	Chemical Interaction with stratospheric composition?
CO_2	Carbon dioxide	Fossil-fuel burning; land-use conversion	Yes	No	No
CH_4	Methane	Ruminant animals; rice paddies; biomass burning; gas and mining leaks.	Yes	Yes	Yes
CO	Carbon monoxide	Energy use; agriculture; biomass burning	Yes	Yes	Not significantly
N_2O	Nitrous oxide	Cultivation and fertilization of soils	Yes	No	Yes
NO_x	Nitrogen oxide	Fossil-fuel burning; biomass burning	Yes	Yes	Yes
$CFCL_3$	CFC-11	Chemical industry	Yes	No	Yes
CF_2Cl_2	CFC-12	Chemical industry	Yes	No	Yes
$C_2Cl_3F_3$	CFC-113	Chemical industry	Yes	No	Yes
CH_3CCl_3	Methyl chloroform	Chemical industry	Yes	Yes	Yes
CF_2ClBr	Halon 1211	Fire extinguishers	Yes	No	Yes
CF_3Br	Halon 1301	Fire extinguishers	Yes	No	Yes
SO_2	Sulfur dioxide	Coal and petroleum burning	Yes, but weak	Yes	No
COS	Carbonyl sulfide	Biomass burning; fossil-fuel burning	Yes, but weak	Yes	Yes

concentrations would increase by more than a factor of three from current levels, while nitrous oxide concentrations would increase by about 20 percent. Although methane has a relatively short lifetime in the atmosphere, it might increase by about 12 percent over current levels.

1.3. GLOBAL WARMING AND CLIMATE MODELS

1.3.1. Historical Temperature Records

Variations in the chemical balance of the atmosphere are a principal cause of climate change. According to fundamental physics and mathematical climate models, the increase in greenhouse gases in the atmosphere will cause an increase in the average global temperature. Analysis of temperature records collected thus far seem to indicate an irregular global warming of 0.3 to 0.6 degrees C. since the late 19th century. Most of this warming was measured before the 1940s, followed by cooling to the early 1970s, warming until 1982, and little change since then. This pattern in time is not what one would expect from a steady increase in greenhouse gas concentrations, largely taking place since the late 1940's. Unfortunately, problems with measurement techniques, observations covering only a limited geographic range, and other factors have limited and contaminated the data sets such that accuracy of this estimate over the hundred-year period is probably limited to a few tenths of a degree. In addition, although the global climate of the past several thousand years is stable to within about one degree, natural factors predating significant industrial activity have apparently caused climatic variation of several tenths of a degree lasting up to a few centuries, particularly around the North Atlantic basin where our observational climate records are best. Thus there is considerable uncertainty about whether the observed increase in this temperature is significant and how much of it may be due to anthropogenic sources rather than natural variation. This uncertainty also constrains a quantitative comparison of temperature records with computer model simulations of greenhouse warming.

1.3.2. Climate Models

Because the climate system is more complex than can be fully represented by a laboratory experiment, and there is insufficient information on past climate changes with which to compare the extent and rates of atmospheric composition changes as they are currently projected to occur, mathematical computer models are the most convenient means for studying climate and climate change. The most comprehensive of these climate models are referred to as general circulation models (GCMs).

Current estimates of the average global temperature increase resulting from the increase in greenhouse gases using current climate models range from about 1.2°C to as much as 5.5°C

for a doubling of CO_2 (or its equivalent in other greenhouse gases) from preindustrial levels, depending on the sequence of various feedback mechanisms. When and if this doubling of CO_2 occurs depends very much on what actions are taken to reduce greenhouse gas emissions. EPA estimates that if past emission trends continue, a doubling of CO_2 could occur as early as the year 2030.

These models, however, are severely limited. They can represent many, though by no means all, of the most important of the processes of the climate system and have undergone a range of verification tests against observations that suggest that they are reasonably accurate in representing present global-scale climate features. However, they are less successful in representing regional climatic features because of the coarseness of their spatial resolution, which is limited to several hundred kilometers. Verification tests also suggest that climate models depict short-term climate changes, such as the seasonal cycle, and long-term equilibrium changes, such as glacial/interglacial changes, reasonably well, but do not describe as well climate changes occurring over periods of decades, primarily because changes on these time scales are poorly understood.

Because of the uncertainties associated with climate models and with future emissions, there is little consensus as to the magnitude of global warming or when or how rapidly it will take place. These characteristics of the temperature change depend largely on the reactions of the earth's geophysical and biological feedback mechanisms to the increased warming, including changes in atmospheric levels of water vapor, snow and ice cover, and the effects of clouds. These feedback mechanisms may decrease or enhance the warming effect caused by the higher concentrations of greenhouse gases, but much is not yet understood about these mechanisms and their effects are generally not included in climate models. Even if understood more fully, some of these processes are difficult to model. Greater knowledge is needed on these factors before reliable predictions about climate change can be made. For these reasons, scientific and economic investigations into the impacts of possible climate change and possible response actions are warranted, as is consideration of preventive and mitigating actions that can be justified for other reasons.

1.4. IMPACTS OF CLIMATE CHANGE

Because the extent of climate change resulting from the increase of greenhouse gases in the atmosphere cannot be accurately predicted, the impacts of this change on human activities and the biosphere are also difficult to predict. Much remains unknown about the dependencies and interdependencies between climate and ecosystems, as well as those among ecosystems and human systems. In addition, most impact analyses are based on climate models and thus incorporate the limitations inherent in these models into the analyses.

Effects of climate change must be considered on three different levels. The "first-level" effects are the biophysical effects; these are the impacts on physical and non-human biological

relationships, such as precipitation and temperature change, changes in soil moisture, interseasonal climate variations, the frequency and magnitude of extreme events such as storms, plant growth, sea-level rise, and others. The "second-level" effects are the socioeconomic impacts that arise from these "first-level" effects, such as the operational and economic impacts on human enterprises dependent on natural resources. These might include effects on farms, water districts, forest product firms, etc. These "second-level" effects lead to "third-level" effects, which are the wider regional, national, and international societal effects. However, there are many interactions and feedback effects within and among these levels. For example, changes in the level of the Great Lakes, and human reactions to these changes, would simultaneously and interactively affect the relationships among aquatic and terrestrial ecosystems of the area, irrigated agriculture development, municipal and industrial water supply, recreation activities, transportation, and hydro-electric power.

Only recently have studies been initiated that recognize these many interactions, and to discuss them in detail is beyond the scope of this report. The following discussion is only a simplified summary of some of the possible first and second-level effects of climate change and limitations to their analysis to indicate why there is increasing global concern about climate change. Table 2 lists some of the known and unknown factors that must be incorporated into a full analysis of these effects.

1.4.1. Climate Zone Shifts

A number of scientists believe that with rapid global warming, areas of a particular climate would shift several hundred miles to the north in the northern hemisphere and south in the southern hemisphere within a century. Shifts in ecologic distribution of tree species, changes in forest composition, and an increase in species extinction may occur if the shift in climate zones should be faster than the natural migration rates of many species. However, changes in ambient concentrations of carbon dioxide may modify likely responses of plants and ecosystems to climate variables, and new species may evolve at a faster rate as new niches are developed. The shift in climate zones may result in a shift in distribution of agricultural cropping patterns, altering grain crop yields in many areas of the country. Changes in technology may offset some of these shifts, and increased atmospheric CO_2 may enhance production of crops with additional tolerance to moisture stress. Because climate models are not effective in determining regional climates, future regional agricultural capacities are difficult to determine. The shift in climate zones may also have an impact on energy systems, although this impact has not yet been well defined.

Table 2. Summary of state of the science and uncertainties in effects of global climate change on the human environment.

Area of Concern	Knowns	Uncertainties
Energy	Probable general direction of effects on conventional energy supply (except hydro) and demand, given a level of average temperature increase. Models and methods for forecasting short-term weather	Regional effects of climate change on weather variables. Effect of climate changes on hydroelectric supply. Effect of climate change on biomass supply, wind energy, and the productivity of ocean thermal and other unconventional resources.
Agriculture	Cultivar responses to climate changes. Greenhouse experiments suggest some plant growth may be enhanced by increased CO_2.	Necessary detailed regional climate forecasts are very uncertain. Farmer responses to changed climate are not clear. Because of these and other considerations, even the direction of effects on specific crops in given locations is uncertain.
Water Resources	Models of watersheds, ground-water supply and some river basins. Relationship of precipitation to runoff and water supply for today's climate.	Necessary detailed regional and temporal forecasts of temperature, precipitation, and other weather variables. Relationships between small-area precipitation and large-basin water supply. Effects of changed seasonality of precipitation. Human institutional response.
Forestry	Mechanisms of climate impacts. Physical models of forest succession for small plots. Estimates and models of world products markets.	Regional weather inputs for forests succession models. Existence of a CO_2 fertilization effect. Response of the forest industry to high rates of climate change.
Air quality	General effects of temperature on severity of inversion episodes.	Likelihood of inversions (require weather forecasts). Synergistic and offsetting effects of pollutant emissions.

Table 2 (Con't)

Area of Concern	Knowns	Uncertainties
Fisheries	Possible changes in geographic distribution of important marine fish stocks. General influence of temperatures on freshwater species.	Quantitative influence of warming on current and abiotic processes. Influence of warming on precipitation and fresh ground water and surface water.
Coastal zone	Possible rates of sea level rise in many locations, given a scenario of temperature change. Costs of coastal defense.	Impact on, and value of, coastal wetland resources. Effects on land subsidence and coastal fresh ground water. Effects of coastal processes such as currents.
Infrastructure	Some data on the influence of weather phenomena on road and building maintenance requirements, utility demand, hydroelectric supply, irrigation works. Influence of sea level on coastal infrastructure.	Relationship of global warming to local weather. Quantitative estimates of infrastructure requirements.
Human health	Some inferential data on the relationship of health conditions to weather episodes, disease vectors, and climate.	Influence of global warming on proximate causes of disease and health conditions. Influence of synergistic and offsetting factors.

1.4.2. Air Quality and Water Resources

Global warming could increase air pollution in urban areas, particularly smog (tropospheric ozone). Some of the effects of climate change that could be a factor in this increase may be the alteration of wind patterns, modification of stagnation periods and associated pollutant mixing parameters, changes in the hydrologic cycle that may result in changes in the removal of pollutant during storms, and changes in photochemical conversion rates for many pollutants. Global warming is expected to accelerate the hydrologic cycle, increasing average global precipitation and evaporation. Climate models, however, do not agree on the direction of this change for many regions of the world. Thus the impact on the quality and quantity of water resources is highly uncertain.

1.4.3. Sea Level Rise

Scientists agree that global warming could cause a rise in sea level through the expansion of oceans and melting of glaciers, although there is disagreement as to its extent. Early estimates of sea level rise due to global warming ranged from 0.3 to 2.0 meters (1 to 7 feet) by 2100. Some recent studies indicate that these estimates might need to be scaled back to the range of 10 to 70 centimeters. Even a modest rise in sea level could prove to be a problem for low-lying regions of the world, such as river delta regions of the United States, Bangladesh, and Egypt. A rise in sea level could lead to shift in wetlands, possibly increasing delta and coastal wetland areas, and could increase problems with salt-water intrusion.

1.4.4. Uncertainties

Analyses of the impacts of climate change are severely limited by problems in both methodology and information. Because these analyses are dependent on predictions of climate change that are highly uncertain, the use of traditional statistical methods to account for this uncertainty severely limits the usefulness of the results. In addition, there is little information available to assess the environmental, economic, and sociologic impacts. Impact assessments of climate change conducted thus far have generally only focused on specific sectors (e.g., electricity) in selected regions, as truly integrated assessments require a substantial commitment of time and resources. In general, numerically and geographically integrated environmental data sets do not exist for large regions, much less any associated economic data sets. Furthermore, there is a problem with data compatibility, as economic and social data are typically collected and reported by political unit while data on natural resources are often collected and reported by habitat type or by physically defined areas such as watershed or soil map units. No standard methods exist for integrating data collected for different spatial units or for defining the

boundaries of study regions. Thus large, integrated data base systems that provide data stored in compatible spatial and temporal formats, with associated analysis and mapping capabilities to conduct integrated studies, are rare. These deficiencies have severely limited analyses of the impacts of climate change.

1.5. RESPONSE ACTIONS TO LIMIT CLIMATE CHANGE

Although response actions could be devised to limit climate change, very little is known about the consequences of these actions or of their effectiveness and efficiency in limiting climate change. Many of the activities that cause emissions of greenhouse gases are fundamental to modern society, and poorly-designed government interventions to change or curtail these activities could severely disrupt the economies of developed and developing nations. For example, coal, the fossil-fuel with the highest carbon content, provides 20 to 30 percent of the energy needs of industrialized nations and almost three-quarters of the total energy needs of China. Limiting global CO_2 emissions by abruptly removing coal as a source of energy could have severe economic effects in these nations. Policies to limit climate change should be designed to ensure that they are both efficacious and cost-beneficial, but information is limited in this regard.

1.5.1 Possible Response Actions

A number of actions could be taken that may help limit greenhouse gas emissions, although the efficacy and cost-beneficial character of these options has not been fully investigated. These actions fall generally into the categories of limiting global climate change and adapting to such change.

Actions to limit greenhouse gas emissions focus primarily on preventing, stabilizing or reducing the anthropogenic emissions of greenhouse gases. Some of these actions include developing alternative energy sources such as nuclear, hydroelectric, photovoltaic, wind, and geothermal technologies. Increasing the efficiency of energy conversion and use reduces greenhouse gas emissions without shifting away from the use of fossil fuels. Specific actions to improve energy efficiency include improving the fuel economy of transportation vehicles and of the transportation system as a whole, requiring greater energy efficiency in buildings, improving the efficiency of household and commercial appliances, improving the heat rates of new and existing power plants, and substituting DC adjustable-speed electric motors in many industrial, commercial, and residential applications. For other gases, such as CFCs, substitute compounds may be found for most applications.

Other measures to limit potential climate change involve capturing greenhouse gases at the source of the emissions and removing them from the atmosphere. Methane can be captured

from landfills and other sources for use as fuel. The most economically attractive means to remove CO_2 from the atmosphere is through photosynthesis; thus preserving global forests helps to limit CO_2 emissions by retaining carbon in the biosphere instead of the atmosphere, as does reforestation efforts. However, there are some questions as to the magnitude of reforestation necessary to make this effective. Boosting farm and forest productivity also helps by reducing the demand for undeveloped land.

Carbon is also taken up annually in grasslands and crops; recycling this carbon through biomass cogeneration and converting to it to ethanol, methanol and organic chemical feedstocks can provide a substitute for part of the carbon emissions from fossil fuels. This has the technical potential to stabilize the atmospheric concentration of CO_2 by closing the carbon fuel cycle in years rather than the tens of millions of years required by fossil fuels.

More general strategies to stabilize the global climate are to control population growth, promote conservation of materials and natural resources, and change the structure of demand for materials. A constantly increasing world population will put increasing pressure on energy use, the world's forests, and the demand for materials. Conserving materials and restructuring the demand for goods and services reduces energy demand, which in turn reduces greenhouse gas emissions. Examples of these actions include recycling materials, recovering resources and reducing waste; substituting low-emission materials for high-emission materials; redesigning products and production processes to require less material; restructuring land-use and business planning to reduce the length or number of trips requiring the use of automobiles and aircraft; and other actions.

Actions to adapt to climate change focus primarily on adapting to those "first-level" impacts discussed above. For example, adapting to climate zone shifts would require changes in the physical and institutional arrangements for water management to maintain or redistribute water for irrigation, water supply, hydropower, navigation, cooling, waste processing, fisheries, flood control, and recreation. There could be a need to monitor cropping patterns or crop varieties. To deal with sea-level rise, advanced economies could respond by building dikes along the coasts, relocating structures, importing water to replace resources lost to sea-water intrusion, etc., even though these actions might involve large costs. Developing countries may find absorbing these costs impossible; in such regions, climate change may create large numbers of persons displaced from their homelands by the changing environment.

1.5.2. Costs and Uncertainties

Very little is known about the costs of implementing measures to control climate change. To date, no U.S. government agency has issued an estimate of the costs of stabilizing or reducing greenhouse gas emissions. The task of making such an estimate is complicated by the fact that past projections of energy use and prices even in the absence of government intervention have been unreliable. It is very difficult to predict rates of technological change

over the time scales that are relevant for energy systems (20 to 30 years), although some governmental analyses of these matters have been undertaken.

Low cost substitutes for fossil fuels used in electricity generation, transportation, heating and cooling, and process heat applications are not currently available, or on the immediate horizon. For the foreseeable future, only lower energy consumption or fuel switching could reduce carbon dioxide that results from fossil fuel combustion. Price increases that are comparable to or larger than the increases from the oil shocks of the 1970s would likely be needed to obtain this change in behavior. On balance, there is no reason to believe that such an attempt to reduce energy use would be significantly less economically disruptive today than it was during those years.

Some preliminary estimates of costs have been made. One report, prepared for the IPCC by Professor Yoichi Kaya of Japan, predicts that if actions were taken to delay a doubling of CO_2 concentration until the year 2090, overall GNP growth rates might be reduced to only one percent per year unless technological change occurred at an unprecedented rate. Another analysis, by Alan Manne of Stanford University and Richard Richels of the Electric Power Research Institute, estimated the costs of response actions to be between $800 billion and $3.6 trillion (in present value terms) through the year 2100. However, analyses by other authors on specific response measures reached different conclusions. For example, Krause et al. (1988) concluded that 29 percent of the predicted residential demand for electricity in Michigan in the year 2000 could be met, at a net savings, by investments in more efficient household equipment. Moskovitz (1989) and Cavanaugh (1989) report that U.S. energy use could potentially be reduced, cost-effectively, by 20 to 75 percent.

These studies indicate that great uncertainties exist in estimating the costs of taking action to reduce greenhouse gas emissions. Just as the possible impacts of climate change are uncertain but potentially significant, so are the costs of limiting climate change. Improved information on both categories of costs is important in order to develop sound policies to address possible climate change.

2. U.S. APPROACH TO ADDRESSING GLOBAL CLIMATE CHANGE

The U.S. approach to addressing global climate change has been delineated by Congress in the Global Climate Protection Act of 1987 and the Foreign Assistance Appropriations Act of 1990, and by the Administration through statements by President Bush, Secretary of State Baker, EPA Administrator Reilly and Secretary of Energy Watkins.

2.1. GLOBAL CLIMATE PROTECTION ACT

The Global Climate Protection Act of 1987 (Title XI of the FY88-89 Foreign Relations Authorization Act - P.L. 100-204) reflects a recognition by Congress of the need for the United States to be involved in both domestic and international efforts to address climate change. This Act recognized that "...the global nature of this problem will require vigorous efforts to achieve international cooperation aimed at minimizing and responding to adverse climate change," and states that the goals of United States policy should seek to:

> "(1) increase worldwide understanding of the greenhouse effect and its environmental and health consequences;
>
> (2) foster cooperation among nations to develop more extensive and coordinated scientific research efforts with respect to the greenhouse effect;
>
> (3) identify technologies and activities to limit mankind's adverse effect on the global climate by-
>
> > (A) slowing the rate of increase of concentrations of greenhouse gases in the atmosphere in the near term; and,
> >
> > (B) stabilizing or reducing atmospheric concentrations of greenhouse gases over the long term; and,
>
> (4) work toward multilateral agreements."

Under the GCPA, the President, through EPA, is also responsible for developing and proposing to Congress a coordinated national policy on global climate change.

2.2. PRESIDENTIAL STATEMENTS

In a series of statements, President Bush has endorsed the IPCC as a process for establishing an international consensus on climate change, expressed a commitment to negotiations on a framework convention on global climate, and endorsed actions that make sense on their own merits.

In May of 1989, the President stated that he had directed the U.S. delegation to the Response Strategies Working Group of the IPCC to move the international community forward in establishing a process for considering how to respond to climate change. He said that the United States looks forward to playing a significant role in global efforts to assess and respond to climate change and expressed an expectation that these efforts will lead to formal negotiations on the establishment of a framework convention on global climate. He noted in particular that:

> "it is important that the (IPCC) process lead to international scientific consensus on the seriousness of the issue for the environment and for the world economy. At the same time, we should ensure that the interests of the developing countries are taken into account in this process."

In a press statement issued in November of 1989, the President declared that "stabilization of carbon dioxide emissions should be achieved as soon as possible," and that "it is timely to investigate quantitative targets to limit or reduce carbon dioxide emissions."

President Bush furthered the commitment of the United States to negotiating a framework convention on global climate change in December of 1989 when, during his summit meeting with Chairman Gorbachev of the USSR in Malta, he offered to host a conference after the IPCC submits its interim report, to begin negotiations on such a convention. He also declared that he would convene an international meeting at the White House in the spring of 1990 for top level scientific, environmental, and economic officials to discuss scientific and economic research related to global change.

The President reiterated his offer of a venue for the first negotiating session of a framework convention on climate in an address to the IPCC in February of 1990. He also outlined some of the actions the United States was taking to address climate change, stating that:

> "we are working with our neighbors around the world to enhance global monitoring and data management, improve analysis, reduce the uncertainty of predictive models, and conduct regular reassessments of the state of science."

He stated further that:

> "even as we wait for the benefits of this research, the United States has already taken many steps...that bring both economic and environmental benefits, steps that make sense

on their own merits in terms of responsibility and efficiency,... (that)...help reduce emissions of CFCs and carbon dioxide and other pollutants now entering the atmosphere....

We are pursuing new technology development that will increase the efficiency of our energy use and thus reduce total emissions.

We're crafting a revise Clean Air Act with incentives for our private sector to find creative, market-driven solutions to enhance air quality.

We've launched a major reforestation initiative to plant a billion trees a year on the private land across America.

And we're working out a comprehensive review and revision of our National Energy Strategy, with initiatives to increase energy efficiency and the use of renewable sources. These efforts, already underway, are the heart of a $336 million Department of Energy program and are expected to produce energy savings through the year 2000 of over $30 billion -- while achieving significant pollution reduction."

In his address, the President also reiterated the need for cost-effective solutions, stating that "as we work to create policy and agreements on action, we want to encourage the most creative, effective approaches. Wherever possible, we believe that market mechanisms should be applied -- and that our policies must be consistent with economic growth and free market principles in all countries."

2.2.1. White House Conference on Science and Economic Research Related to Global Change.

To improve international understanding of both the state of knowledge of science and economic issues relevant to policy on global change and the analytic tools and data required to develop national and international environmental policy, the President hosted an international meeting at the White House in April of 1990, co-chaired by the President's Science Adviser, the Chairman of the Council of Economic Advisers, and the Chairman of the Council on Environmental Quality. By identifying and acknowledging the major gaps and uncertainties in the understanding of these issues, the meeting assisted in the development of a common approach in which the expertise, experience, and data available in the various countries could be brought together in a more integrated and coherent fashion. The results of this conference served as an important input to the IPCC process.

The President, in his opening remarks to the White House Conference, pointed out that the United States is leading the search for response strategies and working through the

uncertainty of both the science and the economics of climate change. He described the need to work out these uncertainties:

> "I see this conference helping to accelerate the IPCC's agenda as it searches for understanding of some very critical questions, broadening the dialogue by exploring the link between scientific research and economic analysis in the study of global change.
>
> What we need are facts, the stuff that science is made of. A better understanding of the basic processes at work in our whole world -- better Earth system models that enable us to calculate the complex interaction between man and our environment.
>
> And yet, as we move forward, all of us must make certain we preserve our environmental well-being and our economic welfare. We know these are not separate concerns. They are two sides of the same coin.
>
> Environmental policies that ignore the economic factor, the human factor, are destined to fail. But there's another reason to consider the economic factor when the issue is the environment. There is no better ally in service of our environment than strong economies. Economies that make possible the increased efficiencies that enable us to make environmental gains. Economies that generate the new technologies that help us arrest and reverse the damage that we've done to our environment."

In his closing remarks, the President strongly stressed our commitment to action:

> "We've never considered research a substitute for action. Over the last two days, you've heard, formally and informally, that the United States is already taking action to stabilize and reduce emissions through our clean air legislation, our use of market-based incentives to control pollution, our search for alternative energy sources, our emphasis on energy efficiency, our reforestation initiatives, and our technical assistance programs to developing nations.
>
> These policies were developed to address a broad range of environmental concerns, in particular our phaseout of CFCs, the impact of our Clean Air Act on emissions, our tree-planting initiative, and other strategies will produce reduction in greenhouse gas emissions that will reach 15 percent in 10 years -- and considerably more later on.
>
> We're also making a leading investment in climate change research -- absolutely essential because it will tell us what to do next. But what bears emphasis is that we are committed to domestic and international policies that are environmentally aggressive, effective, and efficient."

2.3. STATEMENTS OF THE SECRETARY OF STATE

In February of 1989, Secretary of State Baker delineated the primary focal points for U.S. efforts to address climate change. In addressing the first meeting of the Response Strategies Working Group of the IPCC, Secretary Baker stated that four important criteria to be considered in addressing climate change are that:

- o the global community probably cannot afford to wait until all of the uncertainties have been resolved before action is taken, as "time will not make the problem go away;"
- o while scientists refine the state of the knowledge, the global community should focus immediately on prudent steps that are already justified on grounds other than climate change, including reducing CFC emissions, greater energy efficiency and reforestation.
- o global solutions to climate change should be as specific and cost-effective as they can possibly be; and,
- o solutions must reconcile needs for both economic development and a safe environment.

2.4. STATEMENTS BY THE ADMINISTRATOR OF EPA

These points were expanded by EPA Administrator Reilly in outlining the U.S. response to climate change. In a speech at the Noordwijk Meeting in November of 1989, he stated that "there is growing consensus in the scientific community that global warming due to manmade greenhouse gas emissions is possible if current trends in these emissions continue," but that significant uncertainties exist regarding the magnitude and timing and regional variations of global warming. He pointed out that:

- o the United States expects the IPCC process to lead to a framework convention on climate change;
- o the United States has begun several steps to address the global climate change problem, including increasing energy efficiency and reducing CFC emissions;
- o the United States is substantially increasing its budget for scientific research into the causes and consequences of climate change; and,

- o in addition to the multilateral IPCC effort, each country needs to take stock of its own domestic situation and to identify and assess the possible costs and economic effects, as well as the environmental benefits, of measures to limit greenhouse gas emissions or adapt to climate change, and that the United States is committed to assisting in this process.

2.5. STATEMENTS BY THE SECRETARY OF ENERGY

Because many of the actions that can be taken to reduce greenhouse gas emissions involve the energy sector, the Department of Energy plays an important role in defining the U.S. response to climate change. In his statement of July 26, 1989 on the development of the National Energy Strategy, Secretary of Energy James D. Watkins noted that:

> "The potential for global climate change will be central to the development of the National Energy Strategy, because the majority of greenhouse gas emissions and the majority of responses to reduce those emissions necessarily involve the production and use of energy. Six principles form the Department of Energy's approach to global climate change policy:
>
> - o take aggressive action on those issues on which scientific consensus exists;
> - o assess the state of the science on issues where no scientific consensus exists, and identify areas for further inquiry;
> - o where scientific uncertainty exists, move forward with those measures that make sense on other grounds, e.g. efficiency, reducing CFCs and reforestation;
> - o consider the costs and benefits of any response measures suggested;
> - o link responses to scientific and technical information; and,
> - o determine how to evaluate and share technological responses with developing countries."

2.6. FOREIGN ASSISTANCE APPROPRIATIONS ACT

The Foreign Assistance Appropriations Act of 1990 (Public Law 101-167) reflects the sense of Congress that the U.S. foreign assistance program incorporate efforts to help developing countries reduce greenhouse gas emission and address climate change. The Act requests the

Secretary of the Treasury to "promote vigorously" within each multilateral development bank the expansion of programs in areas that address the problems of global climate change and to report to Congress the progress made by each multilateral bank in this regard.

The Act further mandates the Administrator of the Agency for International Development (AID) to:

- issue guidance to all Agency missions and bureaus on a "Global Warming Initiative";

- increase the number and expertise of personnel devoted to energy efficiency, renewable energy, and environmental activities;

- devote at least 10% of the resources allocated for forestry activities to the preservation and restoration of natural forests;

- focus tropical forestry assistance programs on the key middle- and low-income developing countries that are projected to contribute large amounts of greenhouse gases;

- focus energy assistance activities on the key countries where assistance would have the greatest impact on reducing emissions from greenhouse gases.

The Congress also provided authority to AID to use its program funds to retain and increase its direct-hire and other personnel with expertise in the environment sector, in particular with regard to forestry, end-use energy efficiency, and renewable technologies.

3. U.S. ACTIONS TO ADDRESS GLOBAL CLIMATE CHANGE

The United States is currently participating in a number of different efforts that are part of the evolving process to address climate change. These include:

- o efforts to develop and implement policies and practices that limit or adapt to climate change and can be justified for other reasons, including reducing CFC emissions and other greenhouse gases, increasing energy efficiency and exploring alternative sources of energy, and reducing deforestation and promoting reforestation and wise land use both domestically and internationally;

- o efforts, both domestic and international, to reduce the uncertainties surrounding the climate change issue; and,

- o efforts to establish an international consensus on climate change issues, including the state of the scientific knowledge, the impacts of this change should it occur, and possible response strategies.

3.1 U.S. ACTIONS TO LIMIT CLIMATE CHANGE THAT CAN BE JUSTIFIED FOR OTHER REASONS

The United States is focusing its efforts to limit climate change on actions that are also justified on other grounds. These actions include reducing CFC emissions and other greenhouse gases, improving energy efficiency, and reducing deforestation and promoting reforestation.

During his first years in office, the President advanced a large number of initiatives to enhance the quality of the environment. Several of these initiatives, when fully implemented, will result in the substantial reductions in future greenhouse gas emissions in the United States -- at least 15 percent by 2000, and even more in later years. The measures include:

- o Full Phase-out of Chlorofluorocarbons (CFCs)

  The President has committed the United States to seeking an international agreement for a worldwide phaseout of the production and use of CFCs by the year 2000. As a further step, the President signed into law a unilateral U.S. fee on production of CFCs. This will reduce U.S. emissions of CFCs below levels allowed by international protocols.

o The Clean Air Act

The President signed into law amendments to the Clean Air Act calling for two steps that will substantially reduce carbon dioxide emissions:

- A 10 million ton reduction of sulfur dioxide emissions from 1980 levels; and

- A cap on emissions at this sharply reduced level in perpetuity.

These measures in combination create a powerful incentive for energy conservation in the electric utility sector. The amendments also increase the use of alternative fuels and includes measures to reduce carbon monoxide, nitrogen oxides and volatile organic compounds. These measures will result in substantial reductions of greenhouse gas emissions.

o Reforestation

The President has initiated a multi-year program to plant one billion trees annually for the next ten years. This program has the potential, if continued for 20 years, to sequester up to five percent of annual U.S. carbon dioxide emissions.

o Increased Funding for Solar and Renewable Energy and for Energy Conservation

Fiscal Year 1991 appropriations for research and development activities in solar and renewable energy and energy conservation is $198 million, a substantial increase over enacted levels for fiscal year 1990. This research will be critical to identifying technologies that will allow us to meet our energy needs in environmentally efficient ways.

o Energy Saving Appliance Standards

The Department of Energy recently issued new appliance standards that will result in increased energy conservation and reduced energy demand to service affected products. These standards are projected to reduce U.S. carbon dioxide emissions by up to one percent by the year 2000.

o Commitment to Increased Research

In addition to these measures that will reduce greenhouse gas emissions, the President remains committed to a major research effort, the U.S. Global Change Research Program. Spending on global change research in fiscal year 1991 is $954 million, targeted towards investigating the underlying causes, effects and consequences of global change.

3.1.1. Reducing CFC Emissions and other Greenhouse Gases

CFCs and other greenhouse gases have been linked to environmental problems other than climate change that can serve as justifications for a reduction in their emissions. CFCs and other gases containing chlorine molecules have been linked to the depletion of the earth's stratospheric ozone layer, and are believed to be the cause of a hole in the stratosphere that appears over polar regions during the spring months. Carbon monoxide, NO_x, and volatile organic compounds have been linked to the production of tropospheric ozone, or smog, in urban areas. NO_x and SO_2 are associated with acid precipitation. Thus the reduction in emissions of these compounds can be justified for reasons other than climate change.

Reducing CFCs: The Vienna Convention and the Montreal Protocol

The United States is participating in global efforts to reduce CFC emissions as a Party to the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer. Oriented towards protecting the earth's ozone layer, these instruments are international commitments to reduce global levels of CFCs and other fully-halogenated compounds; compounds which are also greenhouse gases. Their implementation is thus a substantive step towards reducing greenhouse gas emissions.

There is also consensus that the format of the Vienna Convention can serve as a model for a broad framework climate convention. The Vienna Convention lays down general principles and obligations for participating nations and provides for a continuing assessment of the scientific aspects of ozone layer modification and its impacts and for response strategies. It also contains provisions for separate protocols containing specific obligations. By using this format for a framework climate change convention, a balance may be struck between the call for a far-reaching action-oriented framework convention and the urgent need to adopt a convention quickly with the broadest possible participation so as to begin tackling the problem of climate change.

Development of the Convention and Protocol

At the behest of the United States, the United Nations Environment Program (UNEP) initiated work in the late 1970's to protect the stratospheric ozone layer. Concern had been growing for a number of years that the widespread use of CFCs was causing irrevocable damage to the stratospheric ozone layer, the protective layer encircling the earth that prevents harmful amounts of ultraviolet radiation from reaching the earth.

In May of 1981, the UNEP Governing Council established a Working Group to negotiate a convention for the protection of the ozone layer. The negotiations began in January of 1982, and the drafting of a convention began in December of that year. The negotiators first tried to establish a convention with controls; when this failed, efforts were shifted to developing a general framework convention, with protocols containing controls to be negotiated separately. After three years of negotiations, an agreement on a framework convention was reached, and, in March of 1985, a Diplomatic Conference adopted the Vienna Convention for the Protection of the Ozone Layer. Due to the uncertainty of the scientific and technical data, negotiators were unable to conclude a protocol at the same time as the framework convention. The Convention was ratified by the United States in August of 1986 and entered into force on September 22, 1988.

Negotiations began again in December of 1986 on a protocol to the Vienna Convention. At that time, it was clear that the workshops and scientific work had been effective in developing an understanding and consensus on the risks involved. No longer were most delegations questioning whether serious controls were necessary; the negotiations instead focused on such specifics as stringency, timing, and chemicals covered. Agreement was reached fairly quickly on these issues, and in September of 1987, in Montreal, Canada, 24 nations and the European Economic Community (EEC) signed the Montreal Protocol on Substances that Deplete the Ozone Layer. The United States ratified the Protocol in April of 1988.

Structure and Content of the Convention and Protocol

The Vienna Convention emphasizes research, monitoring and data exchange, with control protocols to be negotiated separately. Articles 2 through 4 are the most significant, substantive provisions of the Convention, setting out the general obligations of parties to the Convention, establishing areas of cooperation, and providing for the exchange of socioeconomic, commercial, and legal information.

The Convention does not specify any specific action to reduce the global use of CFCs. Article 8 of the Convention provides for the negotiation and possible adoption of protocols, such as the Montreal Protocol. It is through these protocols that coordinated regulatory measures that might be considered necessary for the protection of the ozone layer are implemented.

The Montreal Protocol requires a freeze in the production and consumption of CFCs, at 1986 levels, in 1989. It then requires an additional 20 percent reduction from 1986 levels by 1993, with and a 50 percent reduction by 1998. The Protocol also requires a freeze on the production and consumption of halons, at 1986 levels, by 1992. In addition, it phases in a ban on trade in controlled substances and products containing these substances, discourages the export to non-parties of technology for producing and using controlled substances, prohibits participating countries from concluding new agreements that provide nonparticipants with financial assistance to produce controlled substances, and allows developing countries that are

participants to the Protocol and use little of the chemicals to increase consumption for ten years before being required to abide by the restrictions of the accord.

An important aspect of the Protocol is that it is not static. Because of the many scientific uncertainties, Article 6 of the Protocol calls for periodic reassessments, with adjustments and amendments where necessary, of the control measures established by the Protocol. Should data gathered in these reassessment warrant it, adjustments and amendments to the amounts and timing of the reductions mandated by the Protocol, and chemicals may be added to the list of controlled substances contained in it. The first of these assessments was completed in September of 1989, and the next scheduled assessments will occur in 1994 and 1998.

Reassessments of the Protocol

Since the Protocol went into effect in January 1989, additional scientific data has become available indicating that even with the control measures required by the Protocol, the level of chlorine in the stratosphere would increase from the current level of 3.0 parts per billion (ppb) to a projected level of almost 12 ppb by the year 2100. Thus, many Parties to the Protocol began supporting a complete phase-out of CFCs, rather than a 50 percent reduction, by the year 2000.

In March 1989, President Bush committed the United States to supporting a complete, world-wide phase-out of CFCs and halons by the year 2000. Two months later, in May of 1989, at the First Meeting of the Parties to the Protocol, the nations present signed a non-binding political declaration called the Helsinki Declaration. The Declaration called for a complete phase-out of CFCs as soon as possible, but not later than the year 2000. It also called for a phase-out of halons and other ozone-depleting chemicals (carbon tetrachloride, methyl chloroform and the partially-halogenated chlorofluorocarbons or HCFCs) as soon as is feasible.

The principal issues at this first meeting of the Parties were the timing and content of proposals to strengthen the control provisions of the Protocol, and financial mechanisms to support the secretariat to the Protocol and to assist developing countries in making the transition to safe, substitute chemicals and technologies. The Parties established working groups to develop proposals that would call for the complete phase-out of CFCs and halons and that would require restrictions or a phase-out of carbon tetrachloride, methyl chloroform, and eventually the HCFCs and to develop recommendations on financial and other mechanisms to assist developing countries in implementing the Protocol.

The working groups met in August and November of 1989 and in February and March of 1990. At the November 1989 meeting, the Parties discussed alternative proposals for further restrictions or phase-outs that they would like considered at the Second Meeting of the Parties to the Protocol in June 1990 in London. In addition to these activities, the Working Group on Financial Assistance recommended a series of country-specific studies to determine overall

developing country needs, and called for a study of the potential role of both new and existing funding institutions or mechanisms.

In September of 1989, the first series of the Protocol-mandated UNEP technical assessments on CFCs and halons was completed in which the world experts concluded that a complete phase-out of CFCs by the year 2000 was technically and economically feasible. They also concluded that halons could be phased out by the year 2000, although there was some dissent over whether there should be an exemption for essential uses of these compounds.

At the Second Meeting of the Parties, in June 1990 in London, the parties amended the Montreal Protocol to include a phase-out of CFCs, halons and carbon tetrachloride by the year 2000 and 1,1,1-trichloroethane (methyl chloroform) by the year 2005. The parties also agreed, among other things, to establish ad hoc working groups of experts to investigate and make recommendations on the availability of substitutes for halons, the need to define essential uses of halons, methods of implementation and, if there is such a need, the identification of such uses; and to analyze destruction technologies, assess their efficiency and environmental acceptability and develop approval criteria and measurements. An Interim Financial Mechanism was established, to be succeeded in 1993 by a more permanent mechanism, to provide financial and technical assistance to developing countries so that they may comply with the control measures in the protocol. The Third Meeting of the Parties will be in June of 1991.

Actions by Environmental Protection Agency

The United States, through the Environmental Protection Agency (EPA), has played a key role in the assessment process, chairing the science assessment and co-chairing the technical, economic and environmental assessments that provide the foundation for changes in the Protocol, and is implementing domestically the requirements of the Protocol.

In August of 1988, EPA promulgated final regulations (52 FR 39566) to implement in the United States the controls required by the Montreal Protocol. Several rules were issued during 1989 to clarify these regulations (54 FR 6376, 54 FR 13502, and 54 FR 28062). In addition, EPA issued in July of 1989 a Notice (54 FR 31335) clarifying the classification of recycled CFCs as hazardous wastes (e.g., the applicability of RCRA Subtitle C to CFC refrigerants).

In August of 1989, EPA issued an Advance Notice of Proposed Rulemaking that advised the public that two substances, methyl chloroform and carbon tetrachloride, may be added to the list of controlled substances under the Protocol when the agreement is amended in June 1990, as they contribute to stratospheric ozone depletion. Following the June meeting of the Parties to the Protocol, EPA plans to issue proposed regulations to implement domestically any controls required by the amendments.

To further the recommendations of the Working Group of the Parties to the Montreal Protocol, EPA is now assisting Egypt, Mexico, and Brazil in carrying out studies in those countries. The objectives of these studies are to estimate current and future national demand for CFC's, halons and other ozone-depleting substances, analyze specific uses of these substances, and evaluate control options and costs of reducing these uses. EPA hosted a workshop in January of 1990 for representatives of all developing and developed nations that are participating in these case studies to develop a common methodology for these analyses.

EPA has sent several government/industry missions to China to develop joint projects evaluating options for shifting to alternative, more energy efficient refrigerants. It organized similar joint government/industry missions to the Soviet Union in February, 1990 and to India in the Fall of 1990.

Together with the Industry Cooperative for Ozone Layer Protection, an industry group formed by ten of the nation's largest electronics firms, EPA is providing developing countries with information and technology on CFC alternatives. EPA and the Cooperative are joined together with the government of Singapore to hold a CFC Solvents Alternatives workshop in Singapore in September of 1990. At this meeting, a new, non-proprietary world-wide data base was unveiled. Called OZONET, this database is to provide listings of alternative technologies and up-to-date research on CFC alternatives for all countries.

Fees Imposed on Ozone-depleting Substances

The Omnibus Budget Reconciliation Act of 1989 imposes fees on the production or importation of ozone-depleting chemicals covered by the Montreal Protocol. The base amount for 1990 and 1991 is $1.37 per pound for CFC-11 and CFC-12, rising to $2.65 in 1994, and increasing by an additional 45 cents in each year thereafter. Ozone-depleting chemicals used as feedstocks or recovered as part of a recycling process are exempt from the fees. By requiring the payment of fees to the Government in an amount approximately equal to the market value of limited production and importation rights in exchange for such limited rights will provide an incentive for he speedy development of safe substitute chemicals.

The Clean Air Act

In November of 1990, the President signed into law amendments to the Clean Air Act that builds on the market-based structure and requirements currently contained in EPA's regulations to phase out the production of substances that deplete the ozone layer. Title VI of the amendments, addressing Stratospheric Ozone and Global Climate Protection, requires a complete phase-out of CFCs and halons with interim reductions and some related changes to the existing Montreal Protocol.

Under this title, EPA must list all regulated substances along with their ozone-depletion potential, atmospheric lifetimes and global warming potentials within 60 days of enactment. In addition EPA must ensure that Class I chemicals be phased out on a schedule similar to that specified in the Montreal Protocol CFCs, halons, and carbon tetrachloride by the year 2000 and methyl chloroform by 2002 -- but with more stringent interim reductions. Class II chemicals (HCFCs) will be phased out by 2030. Regulations for class I chemicals will be required within 10 months and for Class II chemicals by December 31 1999.

The law also requires EPA to publish a list of safe and unsafe substitutes for Class I and II chemicals and to ban the use of unsafe substitutes. It requires non-essential products releasing Class I chemicals to be banned within two years of enactment, and aerosols and non-insulating foams using Class II chemicals to be banned by 1994, with exemptions for flammability and safety. Regulations for this purpose are required within one year of enactment, to become effective two years afterwards.

Reducing NO_x and Other Gases

The Clean Air Act

The Clean Air Act amendments are designed to curb three major threats to the nation's environment and public health: acid rain, urban air pollution, and toxic air emissions. The law will achieve significant reductions -- both directly and indirectly -- in greenhouse gases, including sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide and volatile organic compounds.

Title IV of the amendments, the Acid Deposition Control title, will achieve a permanent reduction in sulfur dioxide emissions of 10 million tons below 1980 levels by the year 2000 and a 2 million ton reduction in nitrogen oxide emissions from 1980 levels. These emissions reductions would be achieved in the most efficient and least costly way, providing electric utilities with the flexibility to choose least cost compliance strategies. This flexibility is enhanced by the establishment of an allowance trading system enabling utilities for which emissions reductions are more expensive to purchase emissions "allowances" from those that can reduce emissions more cheaply.

The legislation also caps utility SO2 emissions a 8.9 million tons per year after the year 2000. Without the emissions cap, reduction in SO2 emissions achieved prior to the year 2000 could be offset by growth in utility emissions thereafter, thus negating a fundamental objective of the acid rain program. The emissions cap encourages cost-effective conservation. If a utility can reduce emissions over a 1985-87 base period by generating less, it will have allowances to sell. If a utility meets growth requirements without actually having to generate more electricity

(through demand side management, for example), it will forgo the expense of additional cleanup efforts. The result will be lower SO2 emissions and greater energy efficiency.

Carbon dioxide emissions will be reduced indirectly under this title because the emissions cap and the allowance system provide incentives for energy conservation. The Environmental Defense Fund has estimated that a least-cost acid rain control program such as this one could reduce utility CO_2 emissions relative to current trends by about five percent over the next 15 years.

The incentives for innovative clean-coal technologies provided in Title IV could also result in significant reduction in sulfur dioxide, nitrogen oxide, and carbon dioxide emissions. According to a 1989 report by the Department of Energy, widespread commercial use of clean coal technologies by the year 1020 could reduce sulfur dioxide emissions relative to those from conventional technologies by 29 to 48 percent, depending on the technology chosen by the industry. In addition, emissions of nitrogen oxides could be cut by 14 to 33 percent.

Many of the clean coal technologies can also have positive benefits for reducing the growth in carbon dioxide emissions. Clean coal technologies reduce the release of CO_2 by boosting the efficiency of the poser generating process. Higher efficiency means less fuel is used to generate the same useful energy. For example, a 500 MW plant burning 2.8 percent sulfur coal in a pressurized fluidized bed boiler, and operating at 65 percent of capacity, would emit 2.5 million tons of CO_2 per year, compared to 3.1 million tons for a conventional plant.

Titles I, II, and III of the Clean Air Act amendments call for control measures to reduce carbon monoxide and precursors of tropospheric ozone (volatile organic chemicals and nitrogen oxides). Title I will requires cities not currently in attainment of ambient air quality standards to reduce emissions of volatile organic compounds from stationary and mobile sources by 15 percent within six years, with those in serious non-attainment reducing emissions by at least 3 percent each year after that. The more stringent auto tailpipe emissions standards contained in Title II will also reduce carbon monoxide and nitrogen oxide emissions.

The alternative fuels program contained in Title II is one of the more innovative and far-reaching component of the law. A portion of the motor vehicle fleet in California, and other areas if they desire, will be replaced with new vehicles that operate on clean burning fuels. Besides reducing emissions of tropospheric ozone precursors, the use of alternative fuels will also reduce greenhouse gas emissions. For alcohol fuels, such as methanol and ethanol, the amount of CO_2 released will depend on several factors, including the type of feedstock used, the type of process used, and the energy sources used both for feedstock and fuel production. Assuming the typical feedstocks and processes that are currently used to produce alcohol, slight reduction in CO_2 are produced by using methanol in vehicles compared to using gasoline. More significant reduction in CO_2 are provided by using ethanol. Producing ethanol from biomass reduces CO_2 emissions because carbon is absorbed from the atmosphere by crops as they are grown. The use of natural gas vehicles would result in about a 20 percent decrease in greenhouse emissions compared to the use of gasoline

The Long Range Transboundary Air Pollution Convention (LRTAP)

International efforts to reduce other greenhouse gases are being carried out as part of the Convention on Long-Range Transboundary Air Pollution (LRTAP), signed in 1979 by 35 countries, including the United States, Canada, and the European Community. Parties to the Convention agreed to "endeavor to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution." The Convention entered into force in 1983.

Discussions on a protocol under LRTAP to control emissions of nitrogen oxides were begun in 1985 and formal negotiations began in 1987. The nitrogen oxide protocol was signed by the United States and other countries in October 1988 at Sofia, Bulgaria, although it is not yet in force. The main provisions of the protocol include: (1) a freeze of nitrogen oxides emissions at 1987 levels by December 31, 1994; (2) the use of best available technologies on new sources when economically feasible; (3) a commitment to endeavor to develop a follow-on protocol for nitrous oxides to meet environmental effects control standards, instead of emissions control standards in the present protocol, for implementation in 1996; (4) the exchange of information on control technologies; and (5) increased availability of unleaded gasoline in Europe.

A protocol to the Convention controlling sulfur dioxide emissions was signed by 21 countries, including Canada, in 1985 and entered into force in 1987. The sulfur dioxide protocol requires signatory governments to reduce their 1980 sulfur dioxide emissions levels by 30 percent by 1993. The United States, the United Kingdom, and Poland were among a number of parties to LRTAP that did not sign the protocol. The United States did not sign because it did not consider the required 30 percent reduction justified based on scientific knowledge and because the protocol did not take into account the U.S. leadership in instituting extensive existing control programs in the United States. The U.S. sulfur dioxide emissions declined by 29 percent between the peak year of 1973 and 1983, and by 10 percent between 1980 and 1983.

3.2.2. Increasing Energy Efficiency and Developing Alternate Sources of Energy

A primary justification for improving energy efficiency is economic efficiency. Measures to improve energy efficiency to save a barrel of oil are often less costly than purchasing that barrel. In areas where alternative fuel supplies are scarce, this cost differential can be significant. In the United States, improving energy efficiency reduces our dependence on oil imports and the outflow of dollars used to purchase that oil. In developing nations with few fossil-fuel resources, developing alternative energy sources that are more compatible with local conditions may provide substantial economic as well as environmental benefits.

Efforts to increase energy efficiency are taking place both through bilateral and multilateral efforts and within the United States, and include both energy research and technology development and the practical adoption of more energy efficient technologies.

Energy Policy Analysis and Technology

The Department of Energy

The Department of Energy has a variety of programs in the areas of energy technology research and development, energy technology development, energy policy analysis and international cooperation that have a direct bearing on the global climate change issue.

In nuclear energy, DOE is supporting the development of nuclear production and conversion technologies that can contribute to reducing the time required for the development of nuclear reactors with simplified and standardized designs and passive safety features. This holds the promise of strengthening the nuclear power industry through simplification of the licensing process and cost reduction. DOE's magnetic fusion research program is working to establish the science and technology base for practical fusion energy which, if successfully developed, could provide energy with improved safety and minimal environmental risk.

DOE's renewable energy programs are working to improve and commercialize renewable energy technologies, including biomass, photovoltaics, solar, wind and geothermal power. Fossil fuel development and use programs are underway to promote more cost effective and efficient technologies for power generation and pollution control, which can reduce greenhouse gas emissions compared to conventional technologies.

DOE's conservation program conducts a broad range of R&D and technology transfer activities. These programs are designed to contribute to the development and use of technologies that enhance energy efficiency and the commercial use of new and renewable energy fuels. Spending on solar and renewables was $198.3 million, a substantial increase over the amount appropriated in FY 1990. This increase was focused primarily on developing commercial photovoltaics technology and enhancing biofuels research. Energy conservation research programs are also being emphasized in FY 1991, particularly for transportation, industrial conservation and building systems. Commercial adoption of technologies in these areas have great potential for reducing energy-related greenhouse gas emissions.

Energy technologies potentially have broad international applications. DOE sponsors a variety of bilateral and multilateral efforts to enhance information exchange and R&D cooperation on more efficient and lower emissions energy technologies. Approximately 150 international agreements are in place between DOE and over two dozen countries, including

Australia, Canada, Italy, Japan, China, France, the Federal Republic of Germany, South Korea, Saudi Arabia, Venezuela and the USSR.

DOE is conducting two studies for Congress on energy; one is a review of the potential of alternate energy systems to reduce emissions, the other a compendium of potential private sector responses to climate change, including the development and commercialization of initiatives that contribute to the reduction of greenhouse gas emissions.

Responding to the potential for global climate change through energy efficiency is a central focus of the National Energy Strategy (NES) that is being prepared by DOE. The NES will address those energy actions that can be undertaken - both publicly and privately - to respond to global climate change. The NES will provide specific short-term, mid-term, and long-term recommendations on ways to balance energy, economic and environmental considerations.

The Clean Air Act

As was stated above, the Clean Air Act amendments are expected to spur greater energy efficiency as producers and consumers respond to increased electricity costs brought about by mandated reductions of SO2 and NO_x emissions for existing large, coal-fired power plants. Because flexibility is provided in the means by which these reductions are made, the proposal places energy conservation on an equal footing with control technologies, in contrast to laws that mandate specific control technologies.

International Transfer and Application of Energy Efficient Technologies

U.S. Agency for International Development

Numerous AID projects in the energy sector contribute to reducing emissions of carbon dioxide through improved energy efficiency and renewable energy systems. Specific funds have been allocated in FY 1990 to increase support for projects in these areas as well as in the forestry sector.

AID has provided energy conservation services to twenty-five countries. These services have emphasized conservation primarily in the industrial and electric sectors, but have supported programs in the building and transportation sectors as well. AID is currently working in India, Morocco, Jordan, Egypt, Pakistan, and the Philippines to promote energy conservation, to assist in least-cost energy planning, energy pricing and conservation planning, and to expand the use of renewable energy. Programs on energy efficiency, including policy and institutional

development and technical assistance are also being developed for Eastern Europe, in collaboration with DOE and EPA. Specific projects include:

- o energy audits and assessments of the potential for energy savings in industry;
- o the formulation of national energy conservation policies;
- o the development and promotion of energy-efficient technologies in utilities, industry, and buildings, including technologies that maximize the production of useful energy and minimize the adverse environmental effects of fossil fuel use and electric power generation; and,
- o technical assistance and training.

AID is supporting a number of renewable energy projects in developing nations. Projects in Egypt, Sudan, India, Pakistan and Morocco emphasize energy development, including wind power, solar power, photovoltaics and biomass energy generation, as well as technology development. AID is exploring the feasibility of geothermal energy generation in Kenya, photovoltaic technologies in the Dominican Republic, small hydroelectric power generation in Costa Rica, the production of electricity from bagasse (sugar cane) and rice hulls in the Philippines, Thailand, Costa Rica and India, and wind power generation in several countries throughout the world. AID works with the multi-agency Committee on Renewable Energy Commerce and Trade (CORECT) to enhance U.S. industry involvement in renewable energy activities in developing countries. AID is also working with other donor agencies on many of these efforts, including the World Bank, the InterAmerican Development Bank and the African Development Bank.

3.2.3. Reducing Deforestation and Promoting Reforestation

Reducing deforestation and promoting reforestation can have a significant effect on climate change by increasing the amount of carbon being removed from the atmosphere. These actions have a number of other justifications. They reduce soil erosion and desertification, problems that are significant in parts of Africa and Asia. Preserving and restoring forest habitats address some of the problems associated with the loss of biodiversity. There can be economic benefits; an area of tropical forest has been shown to be of a greater economic value than an equivalent area of cleared land in parts of Africa and Central and South America. For these reasons, the United States is currently carrying out deforestation reduction and reforestation projects both internationally and domestically.

International Tropical Timber Organization (ITTO)

The United States has been actively involved in international efforts to promote conservation and sustainable use of tropical forests. The U.S. participated with the world's tropical forest producing and consuming nations in forming the International Tropical Timber Organization (ITTO), the first international commodity agreement to have a conservation role to play in protecting the earth's remaining tropical forests. Approximately $5.8 million in tropical timber related projects have been approved, with nearly $2.4 million of this amount approved for studies on improved natural forest management in Brazil, Malaysia and Central West Africa.

Tropical Forestry Action Plan (TFAP)

The Department of State, the U.S. Forest Service and AID are participating in the Committee on Forestry of the United Nations Food and Agriculture Organization (FAO). USAID and other U.S. agencies actively participated in the development of the global Tropical Forestry Action Plan (TFAP) under the auspices of the FAO. Under the plan, donors and host-country governments will conduct forestry sector reviews in more than 60 countries within the next seven years. The United States is also participating in follow-up efforts after the International Tropical Forestry Conference, a conference held in July of 1987 to further TFAP objectives, and in an international task force sponsored jointly by the United Nations Development Program, the World Bank and the Rockefeller Foundation to examine mechanisms for strengthening forestry research throughout the tropics.

"America The Beautiful" National Tree Planting Initiative

President Bush has created a new multi-year program of tree planting and forest improvement, called "America the Beautiful," to enhance existing natural and recreational resources and reduce the buildup of carbon dioxide in the atmosphere. The initiative calls for a public and private sector cooperative approach with a goal of planting, improving and maintaining more than one billion trees per year in communities and rural areas nationwide.

The program provides for tree planting and forest improvement in rural areas through technical assistance and cost-sharing with private landowners. Much of the tree planting would take place on non-industrial forest lands and on economically marginal and environmentally sensitive agricultural cropland and pastureland. The USDA Forest Service, through the State Foresters, is providing leadership for this effort. Because much of the tree planting encompasses areas that have not participated strongly in recent tree-planting efforts, such as the Conservation Reserve Program, the program bolsters technical support mechanisms and expertise available to

landowners and ensures the availability of appropriate planting stock. Trees planted in this community program have the potential not only to directly absorb carbon dioxide, but, in many cases, to reduce emissions by saving on energy used for air conditioning.

The proposal also provides leadership in promoting a nationwide volunteer effort to plant an average of 30 million trees annually in the nearly 40,000 cities, town and communities throughout the country, mobilizing the corporate and civic sectors to donate funds and labor. National leadership will be shared by the Forest Service and a national non-profit foundation. The foundation will promote the program, assist the public, corporate and civic sectors in working cooperatively, solicit funds to assist communities, and encourage volunteerism in communities to plant trees. Funds raised by the foundation will be used to assist communities in covering the costs of site preparation and tree selection, planting and maintenance in communities throughout the country.

Department of Agriculture

In addition to the U.S. Forest Service efforts described above, the USDA is undertaking several other international efforts concerning forest resources, including an assessment of the trade potential of forest products to assist reforestation in Argentina. Domestically, the USDA is undertaking reforestation and afforestation programs to offset U.S. carbon dioxide emissions in many of the National Forests and other lands.

Department of Interior

The Department of Interior's Bureau of Land Management is undertaking reforestation projects on over 160,000 acres in the United States, including projects on 80,000 acres of Indian lands.

U.S. Agency for International Development

AID funds over 150 projects worldwide in agroforestry, reforestation, natural forest management, fuelwood production, and forestry research. This includes helping countries formulate improved natural resource management policies that facilitate better management of existing forests and increase reforestation. On an annual basis, about 28 percent of total forestry funding supports reforestation.

For the past decade, AID has been monitoring its development projects for adverse environmental impacts through the Environmental Early Warning System. This has resulted in

substantial alleviation of environmental damage, particularly in the forestry and agriculture sector. The concept of "environmental sustainability" is being vigorously pursued and methodologies for measuring sustainability are being developed for these sectors. AID also monitors projects of the World Bank and regional development banks for adverse effects on climate and the environment, and files semi-annual reports to Congress on potentially damaging projects.

AID's mandate to address global climate change was expanded in the FY90 appropriation bill. This legislation expands funding for global climate change work by $15 million, and places particular emphasis on forestry and energy efficiency.

3.2. RESEARCH EFFORTS TO INVESTIGATE UNCERTAINTIES

The U.S. is by far the largest contributor to research efforts on global change to remove many of the uncertainties surrounding climate change. Areas of research include scientific investigations into climate and climate change, investigations into the environmental, social, and economic impacts of climate change, and investigations into response options, including adaptive measures.

3.2.1. Basic Research on Climate and Climate Change

As was stated in Chapter 1, the ability to predict climate change is severely limited by a lack of understanding of:

- the interactions among the various feedback mechanisms that result in changes in climate;
- the role of oceans in climate change and biogeochemical cycling;
- the processes that control the movement of and interactions among greenhouse gases;
- the interaction of small-scale ecological processes with regional and global-scale processes;
- causes of past rapid climate change and biospheric responses to this rapid change;
- the role of the variation of solar energy output in affecting the earth's climatic processes;

- o the role of the changing atmospheric composition in mitigating the variability of solar energy; and,

- o global emission rates of important greenhouse gases.

Through multilateral research efforts such as the World Climate Program and the IGBP, bilateral research efforts involving a number of different agencies, domestic interagency research programs such as the U.S. Global Change Research Program and the National Climate Program, and agency-specific research projects, the United States is investigating these uncertainties.

World Climate Program

The first of the major international research programs is the World Climate Program (WCP), administered by WMO with active participation by UNEP, ICSU, and the Intergovernmental Oceanographic Commission. Initiated in 1979, the program was formed to coordinate international, climate-related activities. The program consists of four components: the World Climate Data Programme (WCDP), the World Climate Applications Programme (WCAP), the World Climate Impact Studies Programme (WCIP), and the World Climate Research Programme (WCRP). WCP is placing increasing emphasis on the decades-to-centuries time scale in its effort to narrow the range of uncertainties regarding climate change and to refine prediction capabilities. WMO is responsible for the data and applications components as well as the overall coordination of the program, while UNEP coordinates the impacts component. The WCRP is managed jointly by ICSU and WMO. U.S. involvement in the WCRP is coordinated by the National Weather Service.

Major international research efforts in which the United States is participating that are part of the World Climate Research Programme are the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean and Global Atmosphere (TOGA). These are international investigations into ocean phenomena and their interactions with atmospheric phenomena. Intensive planning has been taking place on various aspects of the WOCE program, and some research efforts have been initiated. One significant aspect on which planning is still underway is modeling and predicting the circulation of the ocean and its role in climate change. The United States began implementing a 10-year WOCE plan, with some aspects continuing into the next century.

Joint Global Ocean Flux Study (JGOFS)

Another international program in which the United States is participating is the decade-long Joint Global Ocean Flux Study (JGOFS). The main goal of the JGOFS is to determine and understand on a global scale the processes controlling the movement of carbon

and associated elements in the ocean, and to evaluate the related exchanges with the atmosphere, sea floor and continental boundaries. JGOFS grew out of similar national studies in the United States, the United Kingdom. France. the Federal Republic of Germany and Japan, and is planned to interact with several global geoscience and other major oceanographic programs, including the World Ocean Circulation Experiment (WOCE), the Tropical Ocean and Global Atmosphere (TOGA) study, the Global Tropospheric Chemistry Programme, the International Geosphere-Biosphere Programme (IGBP), the Global Investigation of Pollution in the Marine Environment (GIPME), and the ocean aspects of the World Climate Research Programme (WCRP). The first fully international effort under JGOFS will concentrate in the North Atlantic with extensions into the Arctic Ocean. The participants will include the United Kingdom, the Federal Republic of Germany, Canada and the United States, with U.S. efforts also underway in the Pacific.

International Space Year (ISY)

The year 1992 has been designated International Space Year (ISY). A principal ISY theme that has been adopted for the commemoration is "Global Cooperation on the Space Frontier, Mission to Planet Earth." The Space Agency Forum For ISY (SAFISY), a coordinating body of 25 world space agencies in which NASA participates, is identifying projects contributing to this theme. The SAFISY Earth Science Panel of Experts is examining projects in the following areas: global consequences of land cover change; greenhouse effect; ocean-climate relationships; polar ozone holes; global information systems (GIS); and global change outreach.

International Geosphere-Biosphere Program (IGBP)

A more recent international climate-change research effort is the International Geosphere-Biosphere Programme (IGBP). Launched in September of 1986 by the International Council of Scientific Unions (ICSU) and scheduled to begin in 1992 to last for at least a decade, the IGBP is an ambitious, long-range effort to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment it provides for life, the changes occurring in this system, and the manner in which they are influenced by human actions.

A Special Committee to oversee the definition and implementation of the IGBP was formed in February of 1988. This committee in turn created several coordinating panels to be responsible for developing specific programs in the areas of terrestrial biosphere- atmosphere chemistry interactions, marine biosphere-atmosphere interactions, biospheric aspects of the hydrological cycle, and effects of climate change on terrestrial ecosystems.

Because of its all-encompassing focus, the IGBP is designed to interact with other, ongoing international programs of research in each of the areas described above. These programs include:

- components of the World Climate Research Program (WCRP), particularly the International Satellite Land Surface Climatology Project (ISLSCP), the International Satellite Cloud Climatology Project (ISCCP), the Global Energy and Water Balance Experiment (GEWEX), the Tropical Ocean/Global Atmosphere Program (TOGA), and the World Ocean Circulation Experiment (WOCE);

- UNEP programs such as the Global Environment Monitoring System (GEMS) and the Global Resources Information Database (GRID);

- the Global Tropospheric Chemistry Program (GTCP), jointly coordinated by ICSU and the International Association of Meteorology and Atmospheric Physics (IAMAP); and

- the Joint Ocean Global Flux Study (JOGFS) and the Man and the Biosphere Program (MAB), coordinated by ICSU;

The IGBP is specifically intended to emphasize the study of interactive Earth processes that are not addressed by these programs. Thus far, four areas have been targeted for study:

- the role of oceanic organisms in the global CO_2 cycle;

- the role of biota in the cycles of chemicals in the atmosphere which give rise to the greenhouse gas effect;

- the role of plants in the exchange of energy and moisture between land and atmosphere; and,

- a coordinated effort to recover information from natural archives that will illuminate connections among atmospheric composition, global temperature, ice extent, solar history, and the distribution of land and oceanic organisms.

National programs form the foundation of this effort, to be linked by various bilateral and multilateral activities. Some 30 nations have established national committees for the IGBP, and about 20 nations are providing financial support to the IGBP secretariat.

The United States responded to the call for the IGBP by forming, through the National Academy of Sciences/National Research Council (NAS/NRC), a national committee for the IGBP. This U.S. committee is being funded by EPA, NSF, NASA, NOAA, DOE, DOI, and the Navy, and provides advice to the Government and scientific community about national activities related to global change.

The U.S. Global Change Research Program

The U.S. research effort that interacts with the IGBP is the U.S. Global Change Research Program, created by the Committee on Earth and Environmental Sciences (CEES). To increase the overall effectiveness and productivity of Federal research and development efforts directed toward an understanding of the Earth as a global system, the Director of the Office of Science and Technology Policy (OSTP) established the CEES under the Federal Coordinating Council for Science, Engineering and Technology (FCCSET). The CEES is charged with reviewing and coordinating Federal programs and plans dealing with both national and international activities in earth sciences, earth sciences being broadly defined to include the physical, chemical, and biological processes associated with the atmosphere, oceans, and the land. Within the CEES, a Working Group on Global Change coordinated the development of the Research plan for the U.S. Global Change Research Program.

The U.S. Global Change Research Program is designed to reduce significant scientific uncertainties and to develop more reliable scientific predictions on which sound policy decisions can be based. Because of the high priority attached to this effort, spending on this research increased to $953.7 million, an increase of 45 percent over the FY 1990 level.

In formulating its Research Plan, the CEES drew upon the national and international research plans and recommendations developed by the scientific community that call for a systematic and integrated study of the global Earth system and its susceptibility to change. In particular, the CEES relied heavily on the advice and recommendations of the Committee on Global Change. The goals, objectives, and strategies of the Program are also consistent with the IGBP and the World Meteorological Organization's World Climate Research Programme.

The particular research activities that comprise the Global Change Research Program are grouped into the following seven interdisciplinary scientific elements:

- climate and hydrologic systems;
- biogeochemical dynamics;
- ecological systems and dynamics;
- earth system history;
- human interactions;
- solid earth processes; and,
- solar influences.

CEES is coordinating this program with the many groups currently undertaking global change research. These include the national and international scientific community (both informally and through such groups as NAS and ICSU), government agencies, and intergovernmental science bodies such and the WMO, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and UNEP.

Agencies undertaking research as part of the Global Change Research Program include the National Science Foundation (NSF), the Department of Energy (DOE), the Department of the Interior, the National Aeronautics and Space Administration (NASA), the Department of Commerce through the National Oceanic and Atmospheric Administration (DOC/NOAA), the Environmental Protection Agency (EPA), and the Department of Agriculture (USDA). Many of these agencies, and others, such as the Department of Defense (DOD) and the Smithsonian, also conduct mission defined research that will contribute to research efforts to improve the overall understanding of global climate change. Because the CEES FY 1991 Research Plan issued in October of 1990 describe much of the activities of these agencies in detail, the following summaries focus primarily on the responsibilities of each agency or department as part of the Global Change Research Program, international activities carried out by the agency or department, and activities that are not part of the Research Program.

The National Oceanic and Atmospheric Administration (NOAA)

NOAA maintains a balanced program of observations, analytical studies, climate prediction and information management as part of the national global change program. In the Global Change program, NOAA is responsible for in situ and satellite observations and monitoring programs; research on physical and biogeochemical processes in the climate system; development, testing and application of models and diagnostic techniques for the detection and prediction of natural and human-induced climate changes; and the acquisition, maintenance, and distribution of long-term data bases and related climate information.

Recent NOAA bilateral and multilateral activities have focused on assessing the role of natural climate variability and anthropogenic causes for climate change. Some of these activities include:

- joint studies with India on climate variability and monsoon in 1988;
- funding since 1984 of a specialized oceanographic center in Hawaii to coordinate a Pacific-wide sea level observation network; there are now 30 countries and a total of 76 stations in the Pacific that are part of this network;
- joint American, Canadian, and British studies of how the waters of the Atlantic Ocean and the atmosphere above it process chemicals that influence climate;

- o activities under the U.S.-Soviet bilateral agreement, including climate and paleoclimate studies in the Arctic and measurements of methane and ozone changes in the Arctic and Antarctic regions.

- o joint U.S./PRC comparative studies of climates and agriculture of the North China Plain and the North American Great Plains, monsoon research, Tibetan Plateau and mountain meteorology, global climate, and torrential rains over the Yangtze River basin;

- o cooperative efforts with Brazil to establish a numerical weather and climate prediction facility in Brazil to research the influence of the tropical Atlantic Ocean on regional and global climate; and,

- o studies of the interactions of tropical ocean and global atmosphere as part of the TOGA program with China and France.

Under a Memorandum of Understanding between the U.S. and Canada, the International Joint Commission (IJC) on US-Canada Great Lakes Cooperation has established a number of bilateral, climate-related research programs. NOAA's Great Lakes Environmental Research Laboratory (GLERL) has developed Large Basin Runoff Models that have been instrumental in assessing high water levels in the Great Lakes and have been transferred for use by Canada and the US Army Corps of Engineers. Another area of tri-lateral cooperation with Canada and the USSR involves measuring methane emitted from tundra and permafrost in the Arctic territories.

National Science Foundation

In 1987, NSF initiated a Global Geosciences program for support of studies of the earth as a system of interrelated physical, chemical, and biological processes that regulate the environmental conditions on this planet. This program is now part of the U.S. Global Change Research Program. Specific responsibilities under the Global Change Research Program include maintaining the health of basic research in all areas of Earth, atmospheric, and ocean science, including the relevant biological and social sciences and research in the polar regions. The basic research program is focused on large-scale field programs; interpretation and use of remote-sensing data and geographic information systems; theoretical and laboratory research; research facilities support; and the development of numerical models, information and communication systems, and data bases. Areas of research include global tropospheric chemistry, global ocean fluxes, world ocean circulation, and global ecosystem dynamics.

The Environmental Protection Agency

The Environmental Protection Agency is conducting research to assess at the local, regional, and global scale the future tropospheric composition and the impacts on the climate of the tropospheric chemistry. Both chemical transformations of greenhouse gases and reactive gases that are sources or sinks of greenhouse gases are being examined. Particular attention is being given to biogenic emissions of greenhouse gases.

EPA is investigating soil mediated emissions and sink processes for greenhouse gases in the tropics, high latitudes, and temperate zone, as tropical land use changes, biomass burning and deforestation play major roles in greenhouse gas emissions and tropical air quality. Research in the temperate zones is focusing on agricultural areas, near coastal areas and forested areas.

EPA is currently putting together emissions factors and estimates for greenhouse gases and related reactive trace gases. This work includes evaluating data on significant anthropogenic sources of carbon dioxide, methane, carbon monoxide, hydrocarbons, and nitrogen oxides. Coal-fired boilers, coal mines, municipal solid waste landfills, automobiles, rice cultivation, and natural gas production and distribution are being selectively measured for emissions, and a data framework is being developed to incorporate this information with the biogenic emissions data.

Internationally, EPA is conducting this research to quantify emissions of a number of greenhouse gases with a number of different countries. EPA participated with the Forest Service in the Canadian Mass Burn Experiment, which examined the emissions from large-scale forest burning. EPA is involved in programs in Brazil to investigate the emissions from biomass burning and the effects of tropical deforestation, and EPA is developing bilateral research with the Soviet Union to look at greenhouse gas emissions and biogeochemical climate feedbacks in taiga and tundra ecosystems. Bilateral research in the Peoples Republic of China includes studying methane released from rice cultivation. Other partners in bilateral research include Korea, Japan and the Federal Republic of Germany.

Department of Interior

The Department of Interior (DOI) has been conducting studies of climate change since 1979. Current DOI programs in the Global Change Research Program address the collection, maintenance, analysis, and interpretation of short- and long-term land, water, biological, and other natural resource data and information. These efforts include the monitoring of hydrologic and geologic processes and resources, land use, land cover, and biological habitats, resources, and diversity. DOI research areas also include research into past global change, the hydrologic cycle, land-surface and solid Earth processes that relate to environmental change, geography and cartography, polar and arid region processes, ecosystem modeling and dynamics, and resource

ethnology. To coordinate this research and to advise and assist the Secretary in developing and implementing policies and strategies to understand and be prepared to respond to the potential impacts of global climate change on Department programs, DOI has established the Interior Council on Global Climate Change, chaired by the Undersecretary and comprised of senior policy officials. Internationally, DOI is undertaking several cooperative studies to monitor climate change.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration support earth science research from space, including those studies that study the planet as an integrated whole. Associated efforts include remote sensing and advanced instrument development; the improvement of techniques for the transmission, processing, archiving, retrieval, and use of data; the development of scientific models; and other research activities on the physical, chemical, and biological Earth system processes that maintain global environmental balance and that influence change in this balance.

As part of the U.S. Global Change Research Program, NASA has initiated Mission to Planet Earth, which includes a series of small satellite missions called Earth Probes, several other important precursor missions, and the Earth Observing System (EOS). The Earth Probes include flights of the Total Ozone Spectrometer instrument aboard Soviet and Japanese spacecraft and the NASA Scatterometer is being developed, for a 1995 launch on a Japanese spacecraft, to better understand air-sea interactions. Other precursor missions include the Ocean Topography Experiment (TOPEX/POSEIDON), which is a joint 1992 mission with France to study global ocean circulation. Other nations will conduct several earth science missions at the same time, all contributing toward global understanding of climate change.

Using this information and experience as a guide, polar platforms that make up the proposed Earth Observing System (EOS) will fly in the later half of the 1990's, offering comprehensive measurements of significant earth system parameters for 15 years.

The EOS program includes participation by the European Space Agency (ESA), Japan and Canada. The four partners have been discussing payload planning and mission management issues through the Ear Observations International Coordination Working Group (EO-ICWG) since 1986. The Japanese and Europeans will both be contributing observing platforms and instruments to the program, with U.S. platforms likely to fly foreign instruments and vice versa. In addition, various other research efforts and flight programs involve longstanding international participation.

Department of Energy

The Department of Energy conducts substantial research on the science of climate change, particularly on atmospheric composition, climate models, and the ecological effects of increased CO_2. DOE's work on this issue began in 1977, and DOE was the first federal agency to develop a research program addressing the connection between greenhouse gases (especially CO_2) and climate change. In 1985, DOE prepared a five-volume series of reports presenting the current scientific knowledge of the greenhouse effect.

As part of the Global Change Research Program, DOE's on-going programs focus on scientific questions concerning the atmospheric composition of CO_2 and other greenhouse gases and the effects on climate of changes in atmospheric composition and early detection of these changes, and the ecological effects of increasing CO_2 concentrations.

There is a great deal of international participation in the climate effects and early detection program, which seeks to understand and resolve some of the differences among the General Circulation Models and identify the source of the differences and needed improvements. This efforts involves more than a dozen groups from around the world. A related DOE comparison of radiation models involves more than three dozen groups from around the world.

DOE is proposing a major new research initiative, Atmospheric Radiation Measurement (ARM), to provide the data and understanding of the cloud-climate change feedback and to develop an improved representation of this feedback in the climate change models. This initiative is currently undergoing independent scientific review. Another DOE research initiative seeks to improve the resolution of climate change prediction models by at least a factor of five within the next decade.

Department of Agriculture

USDA is undertaking a number of studies examining the emission and deposition of various atmospheric components, the flow of elements, including carbon, through the ecosystem, and historical studies of climate change. The Cooperative State Research Service is participating in a 200 site network to analyze and measure the deposition of various atmospheric components and is undertaking a special grant program to study the variety of sources, including rice, animal wastes, ruminant digestive processes and wetlands and means of limiting or mitigating methane and other trace gases. The Agricultural Research Service is conducting research programs assessing biogeochemical fluxes from agriculture and rangelands and biological responses to increases ultraviolet radiation. The ARS is also undertaking ecosystem modeling. Finally, the Soil Conservation Service is describing and characterizing soils to provide a standard database for evaluating climate change and is undertaking an paleoecology program to provide a history of these soils.

Department of Defense

The Department of Defense is carrying out mission-defined research that, although not a part of the Global Change Research Program, contributes important data and understanding of oceanographic and meteorological processes and conditions affecting defense operations. Oceanographic research sponsored by the Office of Naval Research and long-term oceanographic observations conducted under the Office of the Oceanographer of the navy, contribute to directed research on global change, especially in the areas of monitoring, assessment, prediction, and data management. The Navy data collection and management experience is important in developing the global ocean observing system network crucial for the early detection of global change. The NOAA and Navy sponsored an Ocean Observation System Workshop in the Fall of 1990 that had significant international participation.

Bilateral and multilateral data exchange agreements for ocean data are currently maintained in order to augment the Navy's data collection efforts. The Navy/NOAA Joint Ice Center provides the only global operational ice forecasts to government agencies, both domestic and foreign, and the public.

Several of the Office of Naval Research projects that may contribute to global change research objectives are conducted in collaboration with other countries. These include on-going involvement in WOCE and TOGA and the following planned and proposed projects:

- joint American, Canadian, British and Norwegian studies of ice lead dynamics and arctic heat flux;
- a study of the breakup of stratus clouds in the marine boundary layer with France and the Netherlands;
- a study of the dynamics of the Kuroshio Current with Japan;
- research on thermocline formation with Germany and France.

Other programs pertinent to the Global Change Research Program are being conducted by the Geophysics Laboratory (Air Force Systems Command) on global cloud cover, by the Defense Nuclear Agency on global circulation of debris clouds, and by the Army's Cold Regions Research and Engineering Laboratory on features of polar climate, such as permafrost distribution and trends.

3.2.2. Research on Impacts

A number of international organizations and U.S. federal agencies are involved in assessing the environmental, social, and economic impacts of climate change. These include the Organization for Economic Cooperation and Development, the Department of Energy, the Domestic Policy Council, the Department of Agriculture, the Environmental Protection Agency, and the Agency for International Development. Many of the U.S. efforts are being carried out as part of the U.S. Global Change Research Program.

Organization for Economic Cooperation and Development (OECD)

EPA, DOE and AID are participating in the Organization for Economic Cooperation and Development (OECD)'s Environment Committee, which is initiating an evaluation of the socio-economic implications for OECD countries of potential global climate change caused by the continuing build-up of carbon dioxide and other greenhouse gases, along with policy options for mitigating any affects. This will involve cooperation with the International Energy Agency in order to evaluate the implications of climate change for energy policy and a comparative analysis of methodologies to analyze socio-economic impacts of climate change.

Department of Energy

In addition to the two studies on energy mentioned previously, the Department of Energy is preparing for Congress an economic analyses of specific emission reduction policies and an identification of greenhouse gas data sources. Other continuing policy activities include emissions analyses and modeling, assessments of physical and environmental system costs, and evaluations of potential response options. In its Ecological Effects program, DOE funds field studies to quantify the effects of increasing CO_2 and climate change on vegetation.

Domestic Policy Council

To support the development of national policies on potential climate change, the Domestic Policy Council's Working Group on Global Change has called for a review and synthesis of information on the economic effects of both climate change and policy options to address climate change. The completion of this report is being directed by the Council of Economic Advisors.

Department of Agriculture

As part of the U.S. Global Change Research Program, the USDA conducts research to assess the effects of global change on the agricultural food and fiber production systems and on forests and forest ecosystems of the U.S. and the world. These projects focus on basic research on the biological response mechanisms to increasing greenhouse gases. In addition to research on energy, carbon, water, and nutrient cycling, and species life histories and community interactions, specific programs being conducted include research on the impacts of global change on:

- o water yields, erosion, and sedimentation;
- o fire severity and occurrence;
- o aquatic ecosystems and fisheries;
- o microbes, plant pathogens and insects; and,
- o impacts of global change on wildlife and domestic species.

The USDA is also investigating the economic impacts of climate change on U.S. agriculture.

Environmental Protection Agency

The Environmental Protection Agency has been conducting investigations into the impacts of climate change since 1983, when it issued the first estimates of sea level rise and the first time-dependent estimates of global warming. In 1990, EPA released the Report to Congress titled The Potential Effects of Global Climate Change on the United States. It is currently expanding and refining this examination by studying different regions of the U.S. and various vulnerable ecosystems.

As part of the U.S. Global Change Research Program, EPA conducts research to assess, evaluate and predict the ecological, environmental and human-health consequences of global change, including the feedback of these systems on climate change. Because changes in the distribution, composition, and condition of vegetation may control the ecological effects of climate change and affect further regional and global climate change through various physical and chemical process, the terrestrial biospheric response to global climate change is being studied. These studies include analyses of forested and water- limited systems to quantity the climate change effects and feedbacks and the effects of enhanced CO_2 on vegetation growth and water use. To investigate the potential climate change on regional scales, EPA is putting

together models for assessing, on both regional and global scales, the interacting factors and feedbacks within the climate system and between the climate and ecological systems.

EPA is examining the impact of climate change on both marine and freshwater aquatic ecosystems. It is conducting research on coastal ocean physics, the response of coastal ecosystems to changes in temperature and solar radiation, nutrient flows between terrestrial and coastal ecosystems, and related material transfers between the oceans and the atmosphere to assess the impacts of climate change on coastal marine systems. To examine the effects of changing temperatures and water availability on freshwater ecosystems, EPA is compiling data on the thermal requirements and distributions of freshwater fish and modeling the effects of various climate scenarios on the water temperature, flow and dissolved oxygen content of rivers and lakes. EPA is also classifying river flow characteristics to establish a baseline for determining the effects of climate change on aquatic systems.

EPA has recently initiated four international projects to examine the global climate change impacts on agriculture, forests, coastal resources, and river basins. These projects, focused mainly on developing nations in Africa, Southeast Asia, Central and South America, are structured to maximize participation of in-country researchers.

Agency for International Development

The Agency for International Development has initiated several research efforts that will improve the understanding of climate change impacts, assess greenhouse gas reduction strategies, and make available technologies potentially useful in reducing greenhouse gas emissions.

Using an AID-supported global network of agricultural researchers, AID and EPA are collaborating to investigate the impact of climate change on the production of food crops. This project will use numerous scenarios of climate change in combination with crop growth models to estimate climate-induced changes in the production of food staples (wheat, rice, maize, and soybeans) in the primary producing and food-deficit regions of the world. The effectiveness of national and international adaptive policies to reduce adverse impacts of climate change on agricultural production and trade will also be evaluated.

3.2.3. Research on Policy Options For Addressing Climate Change, Including Adaptive Measures

The IPCC is the primary international organization investigating policy option for addressing climate change, although the International Energy Agency is also conducting investigations into energy policy options. Domestically, the Council of Economic Advisors, The Committee on Earth and Environmental Sciences, the Department of Agriculture, the

Environmental Protection Agency and the Agency for International Development are examining various policy options for limiting or adapting to climate change.

International Energy Agency (IEA)

In addition to the energy research efforts described earlier in this chapter, the International Energy Agency (IEA) is conducting two major studies of energy policy as it pertains to the environment and climate change in which the United States through the State Department and the Department of Energy, is participating. The first of these, Energy and Environment: a Policy Overview, is a more general examination of environmental approaches relevant to energy activities, including a discussion of possible responsible response strategies and policy choices to achieve both energy security and environmental objectives. The second, Climate Change: the Energy Dimension, undertaken with the OECD Environment Committee, examines technological options for reducing emissions of greenhouse gases and near-term policy responses to reduce energy-related greenhouse-gas emissions. In April of 1989, the IEA held a workshop in which the United States participated on energy technologies for reducing greenhouse gas emissions.

Domestic Policy Council

The Domestic Policy Council's Working Group on Global Change has called for a number of reports investigating policy options for responding to potential climate change. In addition to the review and synthesis of information on the economic impacts of climate change and policy responses discussed previously, the DPC Working Group has requested an investigation into possible roles for the private sector and an analysis of legal precedents for international agreements and conventions to address climate change. The first study is being directed jointly by the Department of the Interior and the Department of Energy, the second by the Department of State and the Department of Justice.

Committee on Earth and Environmental Sciences

In January of 1990, a new working group was formed within the CEES called the Working Group on Mitigation and Adaptation Research Strategies for Global Climate Change, chaired by NOAA. This working group is focusing on scientific, technological and economic research aimed at:

- reducing future growth in emissions of greenhouse gases and increasing sinks for these gases;

- o modifying current technology and practices to adapt to changing climate; and,
- o providing the basis for economic quantification of the impacts of proposed response strategies.

Among other topics, the working group is assessing and considering:

- o the knowledge of current and likely future emissions of greenhouse gases;
- o research now in progress, including cost and feasibility; and,
- o the transfer of technology to developing countries.

The working group will submit to the Chairman of the FCCSET via the CEES annually a report that establishes a coordinated Federal research program with the scope of the committee's charge, including the necessary coordinated budgetary cross-cuts. It coordinates with the Office of Science and Technology Policy and the CEES Working Group on Global Change, as well as the Domestic Policy Council Working Group on Global Change, the National Academy of Sciences, and the Department of Energy to ensure that there is no duplication of efforts. Members of the Working Group include the Council of Economic Advisors, the Council on Environmental Quality, the Agency for International Development, the Department of Commerce, the Department of Defense, the Department of Energy, the Department of the Interior, the Department of State, the Department of Transportation, the Environmental Protection Agency, the Department of Health and Human Services, the Department of Housing and Urban Development, the National Aeronautics and Space Administration, the Nuclear Regulatory Commission, the National Science Foundation, the Office of Management and Budget, the Office of Policy Development, the Office of Science and Technology Policy, the Department of Agriculture, and the United States Trade Representative.

Environmental Protection Agency

The Global Climate Protection Act requires the President, through the Environmental Protection Agency, to develop and propose to Congress a national policy on global climate change. The EPA is working with the Department of Energy to develop a report on strategies to reduce domestic CO_2 emissions by 20 percent and 50 percent by the year 2000 and beyond. The EPA is identifying domestic options that limit greenhouse gas emissions, performing cost analyses of these options, and identifying market and institutional barriers that limit their implementation. In 1989, EPA released a draft report to Congress on policy options for stabilizing global climate change.

EPA is also assessing potential technologies for mitigating the emissions of greenhouse gases. A framework for studying the cost of various technologies is being developed, with

projects directed towards quantifying the efficacy of reforestation, energy efficiency and landfill emissions management strategies. Energy savings from industry, primary metals production, residential use, and electricity generation are being examined, and biomass fuels and landfill gas use schemes are being tested to identify potential mitigation opportunities.

EPA has launched several international projects to identify options that industrial and developing countries could pursue to reduce greenhouse gas emissions at a reasonable cost while meeting the demand for energy and economic growth. Improved information has been gathered on energy use and supply plans in a number of developing and east european countries, including China, Korea, Sierra Leone, India, Indonesia, Mexico, Brazil, Venezuela, Soviet Union, Poland, and Hungary. Practical technologies that are applicable to these countries are being identified and assessed, as is the economic feasibility of selected strategies for different global regions and countries.

Policy studies are also being conducted to explore policy options and societal and institutional barriers to reducing deforestation. Research is being conducted in developing countries such as Brazil, Costa Rica and Kenya to identify alternative forest management and agricultural production techniques that would limit deforestation. Incentives that will encourage countries to employ these techniques which also ensure economic growth and other specific goals will also be analyzed.

At the direction of the President, EPA Administrator Reilly has established a high-level advisory group to find ways to improve the transfer of U.S. environmental technology to foreign countries that otherwise could not afford to pay for it. The International Environmental Technology Transfer Advisory Board (IETTAB) will initially focus on the needs for, obstacles to and solutions to problems of transfer of technologies required by low-income countries to meet the challenges of ozone depletion and global climate change. The board will also study similar issues concerning the transfer of other pollution control technologies and the need for the development of new technologies.

Department of Agriculture

The USDA is developing a number of programs focusing on adaptive strategies for climate change. The Integrated Pest Management program is an ongoing program for the management of economically important pests of crops and livestock to prepare for outbreaks that may occur due to the increased variability in global climate. A program of tree breeding for genetic adaptability to stress also prepares for this variability. Finally, the USDA is conducting a program to introduce exotic tree species that are adapted to future climate and soil regimes into forest ecosystems where native species may not be capable of tolerating increased stress

Agency for International Development

AID is investigating the potential for sustainable alternative agricultural practices to serve as substitutes for the environmentally destructive deforestation that results from slash and burn agriculture and from short-term use of poorly managed pastures in developing countries in the humid tropics. AID, in collaboration with EPA, has commissioned the National Academy of Sciences to assemble a panel of experts to assess the potential of sustainable agriculture to reduce rates of deforestation, to identify requirements for overcoming constraints to adoption of sustainable agriculture, to recommend locations for implementation, and to assess potential environmental and developmental benefits. A series of regional workshops was held in late 1990 to solicit input from developing countries. An international symposium will be held early in 1991 to discuss the expert panel findings.

In the area of energy efficiency, AID is sponsoring research into the constraints to the implementation of policies and financial measures to promote adoption of energy efficiency programs. AID is also supporting research on the most energy efficient and environmentally sound technologies, including the application of fluid-bed combustion technologies of indigenous coal resources in developing countries and the use of advanced turbine technology to improve the efficiency of biomass combustion for electricity generation.

AID is sponsoring work to improve our understanding of the potential effectiveness of climate-change strategies in Africa. These studies are collecting and reviewing available information on carbon cycles for different types of forest and non-forest biomass in sub-Saharan Africa, as well as developing information on trends and projected future contributions of CO_2 and other greenhouse gas emissions. The purpose of this effort is to determine the roles of deforestation, afforestation, and energy generation and use as contributing factors in the global CO_2 balance. The information will help Aid's Bureau for Africa to develop conservation, forestry and energy assistance programs and policies.

3.3. U.S. EFFORTS TO FURTHER INTERNATIONAL CONSENSUS ON CLIMATE CHANGE ISSUES

Efforts to build an international consensus on climate change issues have been focused on the Intergovernmental Panel on Climate Change (IPCC). The scope of the undertaking has established it as the major forum for attempting to reach such a consensus; although a number of international groups are undertaking cooperative research in the many areas of climate change, including the International Energy Agency (IEA), the International Council of Scientific Unions (ICSU), and others, each of these groups is focused on only one particular aspect of climate change. ICSU, for example, is focusing on bettering scientific understanding of global change through its International Geosphere-Biosphere Programme and associated programs, while the IEA is primarily concerned with energy issues. The work of the IPCC is more

comprehensive and has resulted in an assessment of the current scientific understanding of climate change and its uncertainties, the impacts of climate change, and possible response strategies. The effort now involves over sixty nations, several hundred scientists and policymakers, and many non-governmental and international organizations.

3.3.1. International Recognition of the Problem of Climate Change and Consensus on a Process through which it can be Addressed

The international community is now recognizing the common problem of possible climate change and is developing a consensus on a specific process to address it. Through a number of international declarations and agreements, the international community has agreed that:

- o concrete steps should be taken to address possible climate change;
- o although climate change is an international problem that must be addressed through international cooperation, the sovereign right of nations to manage their own agriculture, industries, and natural resources independently must be respected;
- o the IPCC is the central forum to resolve many key issues concerning climate change;
- o negotiations on a framework climate change convention should be initiated following the completion of the IPCC first assessment report; and,
- o immediate actions should be taken to reduce CFC emissions, halt deforestation, and increase energy efficiency.

A number of different international consensus documents outline this process, including UNGA Resolutions 43/53, 44/207, and 45/212; the G-7 Economic Summit Communiques; the Noordwijk Declaration; statements from the Second World Climate Conference and others. The United States both guided the development of and fully supports the consensus reflected in these documents.

<u>UNGA Resolutions 43/53, 44/207, and 45/212</u>

In December of 1988, the United Nations General Assembly, in adopting Resolution 43/53 on the Protection of the Global Climate for Present and Future Generations of Mankind, formally recognized the common problem of climate change and gave its support to the emerging process to address it. The resolution took note that

"the emerging evidence indicates that continued growth in atmospheric concentrations of greenhouse gases could produce global warming with an eventual rise in sea levels, the effects of which could be disastrous for mankind if timely steps are not taken at all levels."

It also urged governments, intergovernmental and non-governmental organizations and scientific institutions "to treat climate change as a priority issue, to undertake and promote specific, cooperative action oriented programmes and research so as to increase understanding on all sources and causes of climate change." The UN called upon "governments and international organizations to collaborate in making every effort to prevent detrimental effects on climate and activities which affect the ecological balance". In endorsing the action of the WMO and UNEP in establishing the IPCC, the UN call upon these organizations to:

"immediately...initiate action leading, as soon as possible, to a comprehensive review and recommendations with respect to:

(a) the state of knowledge of the science of climate and climatic change;

(b) programmes and studies on the social and economic impact of climate change, including global warming;

(c) possible response strategies to delay, limit or mitigate the impact of adverse climate change;

(d) the identification and possible strengthening of relevant existing international legal instruments having a bearing on climate; (and,)

(e) elements for inclusion in a possible future international convention on climate."

The UNGA reiterated its support for the work of the IPCC in adopting Resolution 44/207 Concerning Protection of Global Climate for Present and Future Generations of Mankind in December of 1989. This Resolution also urged governments, intergovernmental organizations, non-governmental organizations and scientific institutions to collaborate in efforts to prepare a framework convention on climate, and recommended that the General Assembly at an early date during its 45th session take a decision recommending ways and means and modalities for pursuing negotiations. It further recommended that governments and competent intergovernmental organizations consider, while awaiting the outcome of the negotiations, the range of possible options for averting the potentially damaging impacts of climate change, for removing the causes of the phenomenon and for developing programs for implementing those appropriate to national need.

In December of 1990, the U.N. General Assembly, in passing Resolution 45/212, reaffirmed the principles embodied in Resolution 44/207 and established an intergovernmental

negotiating process under the auspices of the General Assembly, supported by the United Nations Environment Program and the World Meteorological Organization, for the preparation of a framework convention on climate change. This negotiating process is to take place within an Intergovernmental Negotiating Committee, with the first negotiating session to be held in Washington, D.C. in February of 1991. The convention is to be completed prior to the United Nations Conference on Environment and Development in June of 1992 and opened for signature during the Conference.

G-7 Economic Summit Communiques

At the July 1989 Economic Summit in Paris, President Bush joined leaders of the six other most industrialized nations in recognizing the problem of climate change and the IPCC process to address it. In the communique issued after the summit, these leaders stated that:

> "decisive action is urgently needed to understand and protect the earth's ecological balance. We will work together to achieve the common goals of preserving a healthy and balanced global environment in order to meet shared economic and social objectives and to carry out obligations to future generations."

They advocated common efforts to limit emissions of carbon dioxide and other greenhouse gases which threaten to induce climate change and strongly supported the work undertaken by the Intergovernmental Panel on Climate Change on this issue. They also stated that the conclusion of a framework or umbrella convention on climate change to set out general principles or guidelines "is urgently required" to mobilize and rationalize the efforts made by the international community, with specific protocols containing concrete commitments to be fitted into the framework as scientific evidence requires and permits. Specific support was given to the work of the United Nations Environment Program, the WMO and the IPCC.

At the July 1990 Economic Summit in Houston, the G-7 reiterated its support for the work of the IPCC and the efforts being made in preparation for negotiating a framework convention on climate change. It also welcomed the amendments to the Montreal Protocol, including the creation of a financial mechanism to assist developing countries, and acknowledged that enhanced levels of cooperation are necessary to investigate further the science and impacts of climate change and economic implications of possible response strategies.

President Bush proposed at the summit to begin negotiating as expeditiously as possible a global convention on forestry. The structure of the convention would be modelled on the Vienna Convention, and would be ready for signing at the 1992 United nations Conference on Environment and Development. This proposal was supported by the other leaders at the Summit, who also called requested that the World Bank assist the Government of Brazil in preparing a comprehensive pilot program to counteract deforestation and that the Tropical Forestry Action Plan be reformed and strengthened.

The Noordwijk Declaration

The Noordwijk Declaration on Atmospheric Pollution and Climatic Change, endorsed in November of 1989 by 70 Environment Ministers, including the Administrator of the U.S. Environmental Protection Agency, called for more specific action than previous agreements. The Declaration:

- recognizes the need to stabilize CO_2 and other greenhouse gas emissions while ensuring the stable development of the world economy;
- recognizes the principle of the sovereign right of States to manage their natural resources independently, but reaffirms that global environmental problems have to be approached through international cooperation;
- urges industrialized countries to investigate through the IPCC the feasibility of achieving targets to limit or reduce CO_2 emission levels while ensuring sustainable development and taking into account the specific circumstances of individual countries;
- urges all countries to join and intensify the work of the IPCC in the compilation of elements for a framework convention on climate change so that negotiations can start as soon as possible after the adoption of the interim report of the IPCC; and,
- agrees that developing countries will need to be assisted financially and technically, including assistance with training.

The Declaration also urges all countries to take steps individually and collectively to promote better energy conservation and efficiency, recognizes the need to protect forest resources, and urges all countries to become Parties to the Vienna Convention for the Protection of the Ozone Layer and to the Montreal Protocol. The Declaration is particularly significant in that it represents an endorsement of and a commitment to the IPCC process by many nations that had not previously been active in the IPCC process.

The Second World Climate Conference

The Second World Climate Conference, convened in Switzerland in November of 1990 under the auspices of WMO, UNEP, UNESCO, FAO, and ICSU, discussed the results of the first decade of work under the World Climate Program, the First Assessment Report of the Intergovernmental Panel on Climate Change, the development of the International Geosphere-Biosphere Program, and other relevant global programs. In the statement of the scientific and

technical sessions, which involved 747 participants from 120 countries, the conferees agreed that the "scientific conclusions set out by the IPCC reflect the international consensus of scientific understanding of climate change."

In a Ministerial Declaration associated with the Conference, ministers and other representatives from 137 countries stated:

> "recognizing that climate change is a global problem of unique character and taking into account the remaining uncertainties in the field of science, economics, and response options, we consider that a global response, while ensuring sustainable development of all countries, must be decided and implemented without further delay based on the best available knowledge such as that resulting from the IPCC assessment. Recognizing further that the principle of equity and the common but differentiated responsibility of countries should be the basis of any global response to climate change, developed countries must take the lead. They must all commit themselves to actions to reduce their major contribution to the global net emissions and enter into and strengthen cooperation with developing countries to enable them to adequately address climate change without hindering their national development goals and objectives."

Other Conferences and Declarations

Many other statements issued by other international fora over the last few years stressed the importance of addressing climate change. Among these are the Declaration of the Warsaw Treaty States, the Meeting of Non-Aligned Countries in Belgrade in September 1989, the Tokyo Conference on Global Environment and Human Response Toward Sustainable Development, also held in September 1989, and the Langkawi Declaration on Environment, issued by the Commonwealth Heads of Government in October 1989.

3.3.2. The Intergovernmental Panel on Climate Change (IPCC)

In May of 1987, the Tenth World Meteorological Congress, when discussing the World Climate Programme, asked the WMO Executive Council, in cooperation with UNEP, "to arrange appropriate mechanisms to undertake further development of scientific and other aspects of greenhouse gases." In response to this request, the Council requested the Secretary-General of WMO, in coordination with the Executive Director of UNEP, to

> "explore and, after appropriate consultation with members of the Executive Council, to establish an ad hoc intergovernmental mechanism to carry out internationally coordinated scientific assessments of the magnitude, timing and potential impact of climate change.

> The mechanism developed should avail itself of balanced scientific expertise and provide for participation by governments and organizations."

Concurrent with the request of the Congress, the UNEP Governing Council, at its 14th Session in May 1987, urged the Executive Director to

> "respond positively to the decision by the Tenth Congress of the World Meteorological Organization requesting its Secretary-General, in cooperation with the Executive Director of the United Nations Environment Programme to explore and, after appropriate consultation with Governments, to establish an ad hoc intergovernmental mechanism to carry out internationally coordinated scientific assessments of the magnitude, timing, and potential impact of climate change."

This mechanism, formalized by UNEP and WMO resolutions in 1989, became the Intergovernmental Panel on Climate Change.

The actions of the Tenth Congress, the WMO Executive Council and the UNEP Governing Council arose from the growing international concern about the possible consequences of the increasing atmospheric concentrations of greenhouse gases. In addition to several national scientific assessments made in the United States, a major international assessment was sponsored in 1985 by WMO, UNEP and ICSU and undertaken by the International Conference on the Assessment of the Role of Carbon Dioxide and of other Greenhouse Gases in Climate Variations and Associated Impacts. Known as the Villach Conference, this conference used the results of a major study undertaken from 1983 to 1985 by the International Meteorological Institute in Stockholm as a basis for expressing its concern over the potential seriousness of the issue. Although this was a non-governmental meeting in that the participants attended as individual scientists, it made specific recommendations for actions by governments and intergovernmental organizations for continuing research, monitoring and assessment.

The views and decisions of the WMO and UNEP governing bodies reflected a need for an orderly and intergovernmental process to ensure that research, monitoring, and impact assessment studies proceed in a rational manner, and that international agreement on the results of these assessments exist before legal or regulatory activities be undertaken.

Structure of the IPCC

At the first meeting of the IPCC, in Geneva in November of 1988, the Panel agreed that its main task was to:

- assess the scientific information related to the various components of the climate change issue, such as increases of major greenhouse gases in the Earth's atmosphere and resultant modification of the Earth's radiation balance, that are

needed to evaluate the environmental and socio-economic consequences of climate change; and,

- o formulate realistic response strategies for the management of the climate change issue.

To accomplish this task, the Panel set up three Working Groups. These Working Groups were asked to build on past international and national assessments and draw fully on the expertise of existing international scientific bodies in undertaking this effort. To facilitate coordination among the Working Groups, the IPCC established a Bureau consisting of the three Officers of the Panel (the Chairman, the Vice-Chairman and the Rapporteur) and the Chairs and Vice-Chairs of the Working Groups. Figure 2 shows the structure of the IPCC.

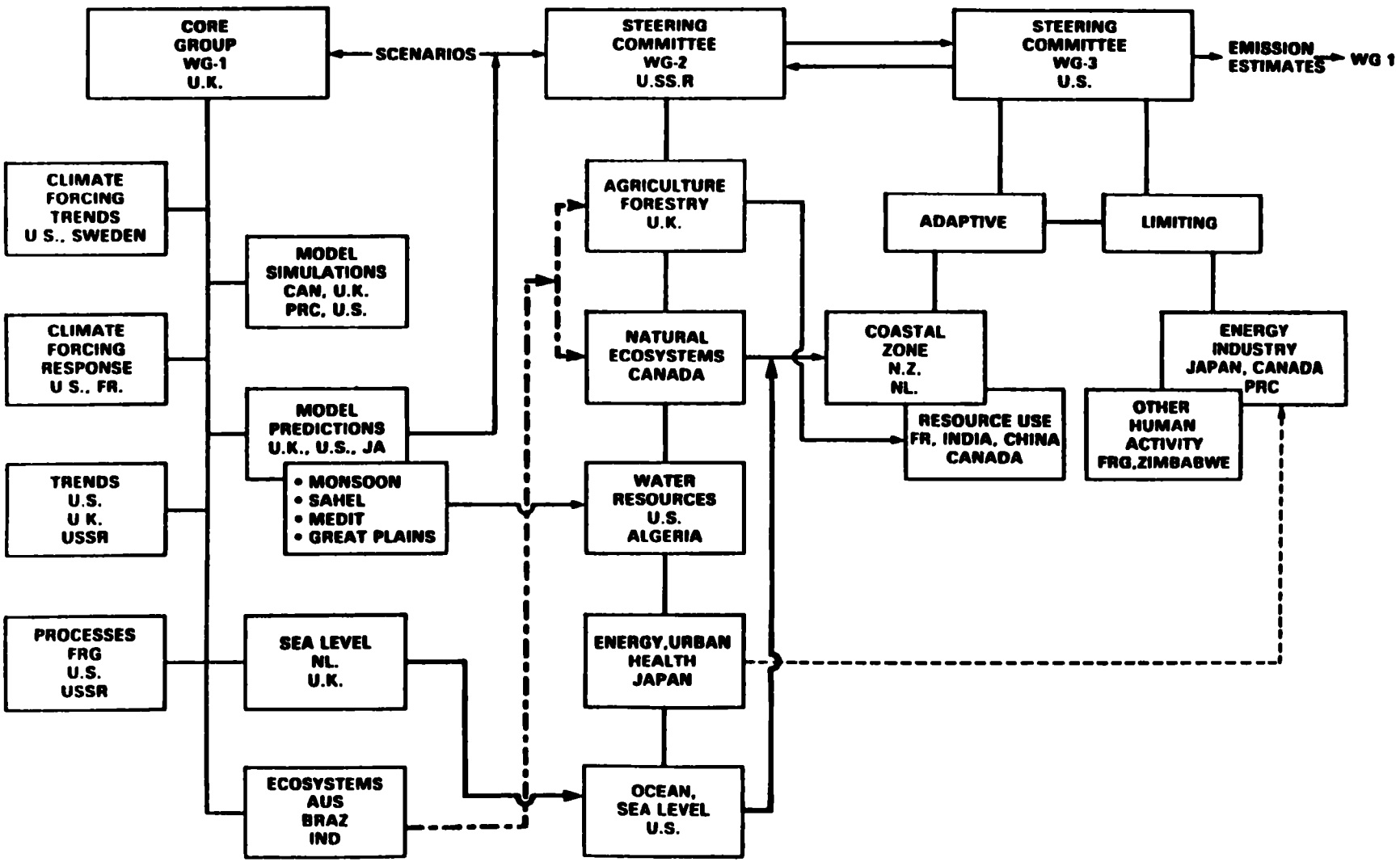
The work of the IPCC has moved quickly. Forty-three nations attended a second meeting of the IPCC in June of 1989, and over 60 attended a third in February of 1990 in the United States and a fourth in August of 1990 in Sweden. The reports of the working groups were integrated into a single report, the First Assessment Report in August of 1990. The overview of this report is contained in Appendix B.

Working Group on Science

Working Group I, chaired by the UK with Brazil and Senegal as the Vice-Chairs, has reviewed the available scientific assessments of climate warming. Special emphasis is has been placed on:

- o recent measurements of greenhouse gases and the new information on their chemistry and tropospheric lifetimes;
- o a critical review of available climate data for detecting trends;
- o evaluations of existing disagreements in model calculations of regional scale climate change (regions are the monsoon region, the Sahel, the Great Plains of North America, the Mediterranean region and Australia; the results of these evaluations will be used in obtaining and interpreting model predictions of regional scale climate change in all other regions of the world);
- o transient climate change calculations;
- o new evaluations of sea level rise; and,
- o future requirements for climate research and observing systems for monitoring climate change.

Figure 2. The IPCC



Thirty international scientists served as lead authors of the assessment, aided by the participation of over 200 scientists from nearly 30 developed and developing countries.

Working Group on Impacts

Working Group II, chaired by the USSR with Australia and Japan as Vice-Chairs, has focused on the impacts of global climate change. The First Assessment Report covers impacts on:

- o permafrost;
- o ecological processes;
- o human settlements;
- o water resources;
- o natural terrestrial ecosystems;
- o world oceans and coastal zones;
- o forests; and,
- o agriculture and land use.

The findings of this working group are linked to those of both Working Groups I and III.

Response Strategies Working Group (RSWG)

Working Group III, chaired by the United States with Canada, China, Malta, the Netherlands and Zimbabwe as the Vice-Chairs, was asked to assess response strategies to global climate change. The working group is concentrating on two broad areas of response strategies: limitation and adaptation. To address limitation strategies, two subgroups were formed, one to focus on energy and industry sectors (including transportation) and the other on agriculture and forestry. The first has been co-chaired by Japan and China and the second by the Federal Republic of Germany and Zimbabwe. To address adaptation strategies, two more subgroups have been formed; one of these, co-chaired by the Netherlands and New Zealand, has been investigating coastal zone management and the other, co-chaired by Canada, France, and India, has been examining resource use and management.

The Working Group undertook as its initial task the development of three emissions scenarios (Task A), which served as the basis for the response strategies and the work being undertaken in by Working Groups I and II. These scenarios anticipate the conditions necessary for the radiative equivalent of a doubling of the atmospheric concentration of carbon dioxide from its pre-industrial value to occur by the years 2030, 2060, and 2090 and stabilizing thereafter. The "2030" scenario has been referred to as the "business-as-usual" scenario; however, since it was not developed as a best guess estimate of the most likely outcome in the absence of major governmental action but as a plausible scenario assuming that CO_2 equivalent doubling took place by 2030, it should not be viewed as a prediction. Another scenario was developed that considers the radiative equivalent of a carbon dioxide concentration of less than twice the pre-industrial value.

The RSWG Steering Committee also examined the implementation mechanisms that could be incorporated into the separate RSWG subgroup reports (Task B). As part of this examination, the RSWG subgroup held a workshop in October, 1989, in Geneva to examine legal and institutional measures, including elements of a framework convention; technology development and transfer measures; financial measures; public education and information; and economic and market mechanisms.

The RSWG report is expected to contain fairly detailed discussions about the implications of implementing key response measures, including to the extent information is available, the costs and benefits of these measures. Currently, very little information is available about the costs and benefits of potential response measures. Future work of the RSWG is expected to focus on the costs and benefits of response options in greater detail.

Energy and Industry Subgroup (EIS)

The Energy and Industry Subgroup (EIS) examined the role of the energy sector in greenhouse gas emissions and possible energy policy and technology responses to climate change. In support of the EIS report, several countries (Australia, Canada, France, the Federal Republic of Germany, Japan, the Netherlands, the United Kingdom and the United States) prepared national case studies, which include a reference scenario and a policy scenario that examines the impact of various policy options in reducing greenhouse emissions. In addition, the United States and Japan prepared a study that examines the results of these assessments, the results of case studies of various developing countries and analyses being conducted by the Department of Energy's national laboratories in collaboration with developing countries scientists and the results of global models to assess the global and regional outlooks. This group has also been requested to investigate emission reduction targets as requested by the participants in the Noordwijk Conference, but the nature of this investigation has not yet been determined.

Agriculture, Forestry, and Other Human Activities Subgroup (AFOS)

The Agriculture, Forestry, and Other Human Activities Subgroup (AFOS) held four workshops in late 1989 and early 1990. Workshops on problems of temperate forests and boreal forests were held in October, 1989 in Bonn and Finland, respectively, and one organized by the US Forest Service on tropical forests was held in January, 1990, in Brazil. A fourth workshop on agricultural problems was held in the United States in December, 1989.

Coastal Zone Management Subgroup (CZM)

The Coastal Zone Management Subgroup (CZM) prepared six papers on:

- the extent and timing of sea level rise and associated climate change effects;
- the impact of sea level rise and climate change;
- problem identification;
- available adaptive options and costs for coastal areas at risk;
- social, economic, legislative, institutional, and environmental implications of adaptive options; and,
- possible funding mechanisms for adaptive options.

It also prepared an inventory of information on technologies and practices for adapting to sea level rise and a regional inventory of existing laws and policies concerning management of development in coastal areas.

In addition to these studies, two major workshops were conducted to review the papers outlined above. One was held in Miami, Florida, in December, 1989, that concerned coastal zone issues in North and South America, Western Africa, Europe, the Baltic States, and the Nordic Countries. The other, in Perth, Australia, in February, 1990, focused on island and tropical countries.

Resource Use and Management Subgroup (RUMS)

The member countries of the Resource Use and Management Subgroup (RUMS) prepared papers addressing the management of water resources, salinization, desertification, forestry,

agriculture, fisheries, animal husbandry, unmanaged ecosystems, and land use in general. "Theme" papers on biodiversity, food security and water resources were also prepared by UNEP, FAO and the Chairman of the American Association for the Advancement of Science's Panel on Climate Change and Water Resources, respectively.

A workshop to discuss these papers and solicit additional ideas about the management of these resources took place in November of 1989 in Geneva. This workshop had sessions oriented around three major themes: water resources, food security and biodiversity, with a focus on adaptive responses that improve the resiliency of resources towards future shifts in climatic regimes while ensuring socio-economic stability and growth.

Participation of Less-Developed Nations

In a meeting in February, 1989, the IPCC Bureau set up a small ad hoc subgroup, chaired by Saudi Arabia, to investigate and make recommendations to the IPCC on means to promote the participation of the developing world in the activities of the IPCC. A report was submitted to the IPCC at its June 1989 meeting, which lead to the creation of the IPCC Special Committee on the Participation of the Developing Countries, chaired by France. This Committee met in September of 1989. The attention of the delegates was drawn to the necessity of quick implementation of short-term measures, including seminars, establishment of national climate committees, training of experts and establishment of effective means of communication, including communication in regard to IPCC activities. A report by this Committee was included in the First Assessment Report.

U.S. Involvement in the IPCC

U.S. scientists and policy makers have provided substantial support to the IPCC in virtually every aspect of the work of the science, impacts, and response strategies working groups. Specific contributions in the science working group are in the investigation of climate forcing trends (with Sweden), climate forcing responses (with France), climate trends (with the UK and the USSR), climate processes (with the FRG and the USSR), model simulations (with Canada, the UK, and the PRC), and model predictions (with the UK and Japan). The primary U.S. contact point for the science working group is the executive secretary of the Committee on Earth and Environmental Science.

With the Impacts Working Group, the United States investigated the possible impact on agriculture, forestry, water resources (with Algeria) and the oceans and sea level rise.

As the chair of the Response Strategies Working Group, the United States, through the State Department, has played the primary coordinating role. As with the other working groups,

U.S. experts have been involved in all aspects of the work of the subgroups, and the United States hosted a number of workshops to consider measures to limit or adapt to climate change. The degree of involvement in this Working Group is such that at a RSWG meeting in October of 1990, over 30 representatives from some 15 executive branch agencies and offices, as well as Congress, were present.

4. U.S. POLICY COORDINATION

U.S. domestic policy on global climate change is formulated by the Domestic Policy Council. The Council depends on its Working Group on Global Change for overall policy coordination, while U.S. policy concerning international climate issues is coordinated by the National Security Council's Policy Coordinating Committee on International Oceans, Environment and Science Affairs (NSC-OES). Research on global change is coordinated by the Committee on Earth and Environmental Sciences (CEES) and the DPC Working Group on Global Change.

To ensure aggressive development of U.S. policy on global change, the President set up a new Working Group on Global Change under the Domestic Policy Council, chaired by his Science Adviser. This working group called for a series of internal studies to provide a basis for this policy development, ensuring that policies are based on sound scientific principles and provide for strong economic growth. The three studies have been underway are:

- o an analysis of economic impacts, chaired by the Council of Economic Advisors;
- o an analysis of the role of the private sector, co-chaired by the Department of the Interior and the Department of Energy; and,
- o a compilation of legal precedent for international agreements and conventions, co-chaired by the Department of State and the Department of Justice.

U.S. policy regarding international climate issues is coordinated by the Department of State through the National Security Council's Policy Coordinating Committee (PCC) on Oceans, Environment, and Science Affairs. The PCC ensures that U.S. diplomatic initiatives at international meetings and conferences accurately reflect, support, and further the policies developed by the DPC and its Working Group on Global Change. All interested Federal agencies are represented on the PCC, which has established a Working Group on Climate Change. This working group has the responsibility for preparing draft reports and documents for consideration by the PCC and ultimate consideration by the DPC Working Group on Global Change, implementing policy and positions for participation in international climate negotiations, overseeing U.S. participation in the IPCC, and organizing all IPCC Working Group 3 meetings. The PCC coordinates closely with the DPC's Working Group on Global Change in all of these areas, and agencies that participate in the DPC Working Group on Global Change are also represented on the PCC, ensuring consistency between the two bodies.

To facilitate the activities of the PCC, the State Department's Bureau of Oceans and International Environmental and Scientific Affairs (OES) has established an Office of Global Change (EGC). This office is responsible for formulating and coordinating the implementation of U.S. global change policy in the international arena. The specific mandate of the Office is to identify, evaluate, and recommend appropriate policy actions regarding political, economic,

legal, scientific, and public relations aspects of U.S. international involvement in global climate change processes, programs, and projects. Since the OES Assistant Secretary chairs the PCC, EGC helps staff this and coordinates with U.S. agencies to prepare U.S. delegations for participation in IPCC Response Strategy Working Group meetings and other international fora.

Direction for scientific research is provided by the OSTP/FCCSET interagency Committee on Earth and Environmental Sciences, chaired by the USGS. The CEES has also instituted a Working Group on Mitigation and Adaptation Research Strategies to coordinate technical and economic research into response strategies.

5. FUTURE EFFORTS TO ADDRESS CLIMATE CHANGE

The nature of future efforts to address climate change is very difficult to predict. Global actions have evolved dramatically over the past several years as some of the uncertainties of climate change and its impacts have been resolved, and can be expected to continue to do so in the future as research continues on the nature of climate change, its impacts, and possible responses. In addition, these actions have developed through international consensus, and must continue to do so. Although each nation may have particular ideals and goals, a spirit of compromise must be maintained with a willingness to accept ideas and initiatives that are most likely to perpetuate this consensus. This need for consensus makes the creation of a long-term strategy for any one nation to address the problem more difficult. For these reasons, a specific long-term course of action for the United States to address climate change cannot be spelled out in detail.

Given this, the United States:

- is striving to facilitate the negotiation of a framework climate convention by offering to host a conference to begin these negotiations following the completion of the IPCC first assessment report;

- has agreed that industrialized nations should, as soon as possible, stabilize emissions of greenhouse gases not controlled by the Montreal Protocol, at levels to be considered by the IPCC and the Second World Climate Conference;

- is continuing efforts to take steps domestically that are justified on grounds other than climate change, such as reducing CFC emissions; increasing energy efficiency; and reducing deforestation and increasing reforestation.

- is continuing efforts to assist other nations in taking these steps as well; and,

- is continuing efforts to refine the state of knowledge climate, the potential impacts of climate change, and possible response measures.

Many of these efforts are still in their formative stages.

5.1. INTERNATIONAL POLICY DEVELOPMENT

5.1.1. Future Work of the IPCC

As was described in Chapter III, the IPCC has completed its First Assessment Report, which provides a detailed, comprehensive analysis of the state of scientific understanding of climate change and associated uncertainties, the impacts of climate change, and possible policy and technology strategies for responding to such change. It also provides possible elements for inclusion in a climate convention and outline to the extent possible the primary issues that must be negotiated.

The IPCC, during its third plenary session in February of 1990, agreed that it should continue its work after the first assessment report of the IPCC. The nature of this work has not yet been determined. As requested by the attendees of the Noordwijk Ministerial Conference, it may include investigating quantitative emission target options to limit or reduce CO_2 emissions. Revisions may be made to its terms of reference if appropriate. The IPCC Bureau will be meeting in February of 1991 to discuss this further.

5.1.2. Climate Convention

Negotiations on a framework climate convention will commence in February of 1991 in Washington, D.C. in accordance with U.N. Resolution 45/212. As part of its consideration of response strategies to climate change, the IPCC outlined possible elements for inclusion in such a convention. Although consensus exists on a number of general issues, there remains significant disagreement on many other issues. An appropriate balance must be struck between the desires of some for a convention that includes specific and far-reaching obligations on one hand and the need for a good, workable instrument, laying down the general principles that can find the widest posible acceptance, on the other.

U.N. Resolution 45/212 dictates that the first negotiating session will occur in February of 1991. Further meetings are expected to be held in May or June of 1991, September of 1991, and, as appropriate, between January and June of 1992. The convention is to be ready for signature at the Conference of the United Nations on Environment and Development in 1992.

There exists a broad consensus that a climate convention should generally follow the format of the Vienna Convention for the Protection of the Ozone Layer. The framework convention would lay down general principles and obligations and provide for a continuing assessment of the scientific aspects of climate change, its impacts, and response strategies. There is also broad agreement that the framework convention should contain provision for protocols to be negotiated separate from the convention to deal with specific obligations.

Participants in the Noordwijk Ministerial Conference on Atmospheric Pollution and Climate Change agreed that a convention should be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced spread of countries. They agreed that the convention and associated protocols should commit the parties inter alia to:

- o enhancement of research and systematic observation of climate, aimed at detecting and monitoring climate variations and change;
- o action to deal with greenhouse gas emissions and the effects of global warming;
- o address the particular financial needs of the developing countries in the access to and transfer of technology; and,
- o strengthen sustainable forest management.

The Ministerial Declaration from the Second World Climate Conference reiterated and expanded on these points.

Through the course of the work of the IPCC's Response Strategies Working Group on implementation measures for addressing climate change, many countries noted the need to go beyond the Vienna Convention either by strengthening procedures for financial and technical assistance to developing countries, strengthening research and development provisions, enhancing research and development provisions, enhancing institutional authority or incorporating general greenhouse gas emission control objectives in the convention itself. Issues raised that may prove particularly contentious during negotiations were the inclusion of emissions control provisions in the convention itself, the need for less-developed countries to increase emissions over the short term, the need for a climate fund or other financial assistance, and the issue of LDCs receiving technology on preferential and non-commercial terms. Several nations have proposed language on intellectual property rights that directly conflicts with language proposed by the United States. It is very difficult to predict how quickly these differences will be resolved or the nature of their resolution.

5.2. U.S. POLICY INITIATIVES

National policy addressing climate change is developing concurrent with the evolving international consensus. Initiatives that have been proposed as part of this policy development stress the need to improve the understanding of climate and recognize the social and economic impacts of possible response measures and the importance of developing response measures to climate change that operate in an equitable and economically efficient and effective manner, and that encourage innovation and diversity in the means of addressing climate change.

5.2.1. Initiatives and Future Efforts in International Fora

Consideration of New Approaches to International Response Measures

To further the development of response options to climate change that operate in an equitable and economically efficient and effective manner, and that encourage innovation and diversity in the means of addressing climate change, the United States submitted materials to the IPCC's Response Strategies Working Group suggesting consideration of two approaches to climate change response measures: a "comprehensive" approach that would treat all greenhouse gases, their sources and sinks; and an "emissions trading" approach that would allow two or more nations to achieve compliance with their aggregate emissions limit while reallocating their emissions among themselves. These approaches were discussed further in an informal seminar for RSWG Officers in February of 1990. These approaches are suggested for discussion in recognition that:

- o greenhouse gases and their sources and sinks are interrelated and there are environmental, economic and equity benefits to treating them collectively;

- o the focus of international response measures is on overall greenhouse gas emissions objectives, and each country should have maximum flexibility in directing its institutions and policies to achieve these objectives;

- o there are environmental, economic and equity benefits to affording countries the flexibility to meet their aggregate global climate change objectives through joint arrangements of policies affecting sources and sinks of greenhouse gases.

A comprehensive approach to curtailing greenhouse gas emissions would stand in contrast to piecemeal, single-gas approaches, and would better enable countries to find economically efficient and institutionally appropriate measures to stabilize or reduce net emissions while achieving economic growth. The approach would focus on the collective potential of greenhouse gases to change the climate, rather than on individual greenhouse gases. Countries would be free to select and to make trade-offs among gases according to the gases relative impacts on climate change, and between restricting sources of gases or enhancing the sinks for these gases (e.g., increasing reforestation efforts), as long as these were consistent with a negotiated "collective" greenhouse gas target. A comprehensive approach could:

- o improve environmental protection by addressing all greenhouse gases, rather than leaving important gases uncontrolled;

- o encourage economically efficient approaches within countries by permitting each country to meet its emissions target through the mix of internal policies

addressing the sources and sinks of the various greenhouse gases that it determines is best suited to its institutional and socioeconomic circumstances;

- o facilitate international action by reducing the divisive inequities posed by single-gas approaches, and by reducing the number of separate protocols to be negotiated, as greenhouse gases would be addressed collectively;

- o provide incentives to develop and use cost-effective, energy-efficient industrial and consumer products, emission control technologies, and reforestation and agricultural policies, thus avoiding the obstacles to technological innovation that typically accompany the "command and control" approach to the regulation of pollutants.

The second approach suggested for consideration is "emissions trading." This approach is compatible with, but separable from, the "comprehensive" approach. Emissions trading has been employed in U.S. domestic environmental policy with considerable success, showing improved environmental protection at substantially lower cost. Examples include the phasedown of leaded gasoline and emissions trading programs developed under the Clean Air Act. A system of international emissions trading would permit nations to achieve their overall obligations through joint reallocations of their individual emissions, thus permitting emissions limits to be achieved most where they are least costly. This approach could help sustain economic growth and development, as developing nations could exchange low-cost emissions reductions for financial assistance from developed nations. It would also provide nations with continuing incentives to achieve additional reductions in emissions through innovative, least-cost investments. Because trading could act as a safety valve if the costs of emissions reductions within a country were more expensive than anticipated, it may also serve to facilitate the development of a protocol to a climate convention.

Each of these concepts raises important issues for further consideration and inquiry, and is discussed in more detail in Appendix C.

5.2.2. Domestic Initiatives and Future Efforts

Domestically, the U.S. research community will continue to strive to reduce the many uncertainties surrounding climate change, but a timetable for such reduction does not exist. The United States will pursue the research efforts outlined by the CES in the document "Our Changing Planet: the FY 1991 Research Plan" issued in October of 1990. These reports outline an accelerated, focused research strategy designed to reduce key scientific uncertainties and to develop more reliable scientific predictions on which sound policies responding to global change can be based. Increased emphasis will be placed on prevention and mitigation strategies and the impacts of these strategies, particularly through the CEES Working Group on Mitigation and Adaptation Research Strategies for Global Climate Change. The total funding available in fiscal

year 1991 for global change research is more than $953 million dollars because of the importance of this area.

Actions to limit or adapt to climate change that are justified for reasons other than climate change will also continue, and will be expanded where feasible. As a Party to the Montreal Protocol, the United States remains intent on phasing out CFC use by the year 2000, and will continue the efforts described in this report to carry out this commitment. Energy policy and technology responses to global climate change will be key considerations in the development of the National Energy Plan. The United States is committed to the National Tree Planting Initiative, which has as its goal the planting of one billion trees annually. This includes planting trees on 1.5 million acres per year on U.S. forest land and planting 30 million trees per year in communities. Finally, as has been described in this report, the United States remains committed to assisting all nations and the international community, through AID, EPA and other agencies, in developing national strategies, policies and programs to address climate change.